1980

Pelagic amphipods (Amphipoda: Hyperiidea) of the continental shelf in the Middle Atlantic Bight

Russell Allen Short
College of William and Mary - Virginia Institute of Marine Science

PELAGIC AMPHIPODS (AMPHIPODA: HYPERIIDEA) OF THE CONTINENTAL SHELF IN THE MIDDLE ATLANTIC BIGHT

A Thesis

Presented to

The Faculty of the School of Marine Science of

The College of William and Mary in Virginia

In Partial Fulfillment

Of the Requirements for the Degree of

Master of Arts

---

by

Russell Allen Short

1980

APPROVAL SHEET

This thesis is submitted in partial fulfillment of the requirements for the degree of

Master of Arts

Russell A. Short

Russell Allen Short

Approved, October 1980

George C. Grant

George C. Grant, Ph.D.

Morris H. Roberts Jr.

Morris H. Roberts, Jr., Ph.D.

Marvin L. Wass

Marvin L. Wass, Ph.D.

Christopher S. Welch

Christopher S. Welch, Ph.D.

Thomas E. Bowman

Thomas E. Bowman, Ph.D.
Smithsonian Institution

TABLE OF CONTENTS

Table of Contents (continued)

ACKNOWLEDGEMENTS

Several people deserve recognition for their valuable assistance and suggestions during the production of this thesis.

Dr. George C. Grant, my committee chairman, deserves a special vote of thanks for the guidance he provided in the developmental and organizational stages of this thesis.

Dr. Morris H. Roberts, Jr. was most helpful with format suggestions and in reviewing the text.

Dr. Christopher S. Welch and Dr. Marvin L. Wass supplied helpful criticisms in the preparation of the thesis.

Dr. Thomas E. Bowman provided valuable assistance with several specimens that proved difficult to identify. He also supplied comments on the manuscript content.

The author wishes to express his appreciation to the staff of Planktology, namely: John E. Olney, Stephen P. Berkowitz, Peter O. Smyth, Cathy J. Womack, Michael Vecchione, Patricia A. Crewe, and Jo Ellen Sanderson, who were all part of the sampling and sorting contingent.

Finally, although by no means last, thanks go to my wife, Cheryl. She provided continual encouragement and support throughout my graduate studies. Most importantly, she typed all of the untold drafts and the final copy of this thesis.

LIST OF TABLES

List of Tables (continued)

LIST OF FIGURES

ABSTRACT

The hyperiidean amphipods were analyzed from samples collected in the Middle Atlantic Bight during five quarterly cruises beginning in October 1975 and ending in November 1976. A total of 23,222 specimens were identified which belong to 63 species in 12 different families.

Two species, *Parathemisto gaudichaudi* and *Lestrigonus bengalensis*, clearly dominated both surface and subsurface assemblages, contributing over 99% of the abundance of both assemblages. *Parathemisto gaudichaudi* was dominant in four of the five cruises with cruise 04W being dominated by *Lestrigonus bengalensis*. These two species occupied virtually the same locale with minor variations in the optimal seasonal conditions. *P. gaudichaudi* followed the classic dawn/dusk double peak vertical migrational pattern except during the May 1976 cruise when a single predominant peak occurred.

The organisms were categorized based upon abundance patterns and occurrence patterns for both the surface and subsurface assemblages. From these groupings, the species were considered as rare, frequent, or abundant and inshore, offshore, or transshelf.

The hyperiidean amphipod community of the Middle Atlantic Bight is a mixture of cold water northern species with an influx in the summer of warm water species.

PELAGIC AMPHIPODS (AMPHIPODA: HYPERIIDEA)
OF THE CONTINENTAL SHELF IN THE MIDDLE
ATLANTIC BIGHT

INTRODUCTION

According to Bowman (1960), the hyperiidean amphipods represent the third most abundant taxon of the marine planktonic Crustacea. Since greatest abundance occurs in the cooler parts of the oceans, the hyperiideans should play an important role in the plankton of the temperate Middle Atlantic Bight. Even though plankton samples have been collected on many cruises conducted in the waters overlying the continental shelf of the northwest Atlantic Ocean, very little detailed work has been completed on the pelagic amphipod ecology. This lack of work may have resulted from systematic difficulties. Recently, Bowman (1973) revised the systematics of the family Hyperiidae and Bowman and Gruner (1973) revised the systematics to family level of the suborder Hyperiidea thus simplifying the identification process.

The hyperiideans have evolved many different techniques to support the pelagic role of the suborder. Many species have evolved strong swimming abilities, e.g. *Parathemisto* spp., while others have evolved into symbionts, e.g. *Hyperoche* sp. (Bowman et. al. 1963). H. von Westerhagen (1976) noted that while adult *Hyperoche medusarum* is mainly free swimming, the juveniles are commensal with hydromedusae. In two recent papers, Harbison, Briggs, and Madin (1977) and Madin and Harbison (1977), analyzed samples collected by scuba divers using jars. The samples contained salps and other gelatinous forms such as Cnidaria and Ctenophora from which the authors identified numerous species of hyperiideans as symbionts. Shih (1969) observed females of the genus Phronima brooding young inside of tunicates.

The food habits of hyperiideans have received only moderate attention. In laboratory studies, Sheader and Evans (1975) found copepods, chaetognaths, Ammodytes larvae, and clupeid larvae to be important prey for Parathemisto gaudichaudi. Westerhagen (1977) found fish larvae, decapod larvae and copepods were important food sources for Hyperoche medusarum. In contrast, the two families, Parascelidae and Platyscelidae, have greatly reduced mouth parts which would indicate a food requirement of soft tissue.

It is still unclear what role certain families and genera fill in marine ecology. The Oxycephalidae is a very unusual family in which many genera are extremely long and thin; for instance, Rhabdosoma sp. resembles a 50mm piece of thread.

Hyperiidean amphipods have been identified in several studies of the continental shelf plankton of the northwest Atlantic Ocean. The species identified and the investigators who reported the species are presented in

Table 1. Included are studies by Holmes (1905), Bigelow (1915, 1917, 1922, 1926), Bigelow and Sears (1939), and Grice and Hart (1962). Bigelow (1915, 1917, 1922, 1926) provided the most detailed information regarding the distribution of the shelf hyperiideans. His studies of 1915 and 1922 dealt specifically with the area sampled during the present study. *Euthemisto bispinosa*, *E. compressa*, *Hyperoche abyssorum*, *Phronima sedentaria*, *P. atlantica*, and *Vibilia* sp. were all taken in the area of the Middle Atlantic Bight. Bigelow and Sears (1939) noted the genus *Euthemisto* rivaled *Calanus finmarchicus* in frequency of occurrence. Sears and Clarke (1940) reported on samples collected from several years in the shelf waters between Cape Cod and the Chesapeake Bay. These authors noted that *Euthemisto* spp. contributed a significant portion to the shelf plankton in only one of four years. Whitely (1948) when studying the larger planktonic Crustacea of Georges Bank, found *Themisto* spp. present in greatest concentration during the night.

Through the work of Bowman (1960), Kane (1966), and Sheader and Evans (1974), several species have been synonomized with *Parathemisto gaudichaudi*. The species identified from the study area during past cruises which are now considered to be *P. gaudichaudi* are: *Euthemisto bispinosa*, *E. compressa*, *Parathemisto gracilipes.*

Grant (1979) has identified the major zooplankton components of the surface and subsurface communities of the

TABLE 1

RECORDS OF PAST OCCURRENCES OF HYPERIIDEANS ON THE CONTINENTAL SHELF BETWEEN CAPE COD AND THE CHESAPEAKE BAY (LISTED BY AUTHOR)

Holmes (1905)	Bigelow (1914-1926)	Bigelow and Sears (1939)	Grice and Hart (1962)
Euthemisto bispinosa	*Euthemisto bispinosa*	*Euthemisto bispinosa*	*Anchylomera blossevillii*
Euthemisto compressa	*Euthemisto compressa*	*Euthemisto compressa*	*Hyperia atlantica*
Hyperia galba	*Hyperia galba*	*Hyperia* sp.	*Hyperia fabrei*
Hyperia medusarum	*Hyperia medusarum*	*Phronima* sp.	*Hyperia macrophthalma*
Hyperoche abyssorum	*Hyperoche abyssorum*		*Hyperioides longipes*
Phronima sedentaria	*Oxycephalus* sp.		*Hyperoche medusarum*
	Parathemisto oblivia		*Paraphronima gracilis*
	Phronima atlantica		*Parathemisto gaudichaudii*
	Phronima sedentaria		*Parathemisto gracilipes*
	Phronimella elongata		*Phronima macropa**
	Phrosina semilunata		*Phronima semilunata**
	Tyro atlantica		*Phronima stebbingi*
	Vibilia sp.		*Vibilia armata*
			Vibilia borealis

*Synonymous with *Primno macropa* and *Phrosina semilunata* (personal communication T. E. Bowman)

Middle Atlantic Bight. He found Parathemisto sp. contributed a substantial portion to the plankton abundance. His findings will be reviewed more thoroughly in the discussion.

After reviewing the available literature, it is evident that since the early studies by Bigelow, very little progress has been made in describing the distributional patterns of the hyperiidean assemblages in the Middle Atlantic Bight. The present study provides species identifications and describes distributional patterns among the hyperiidean assemblages from the collections of Grant (1979).

The objectives of the present study were:

1. To provide a brief descriptive technique to identify to family those species of hyperiideans found during this study.

2. To describe the hyperiidean species occurrence on the continental shelf in the Middle Atlantic Bight during this study of 1975-1976.

3. To compare the observed abundances of several important species.

4. To examine the similarities and differences in the surface and subsurface assemblages.

METHODS AND MATERIALS

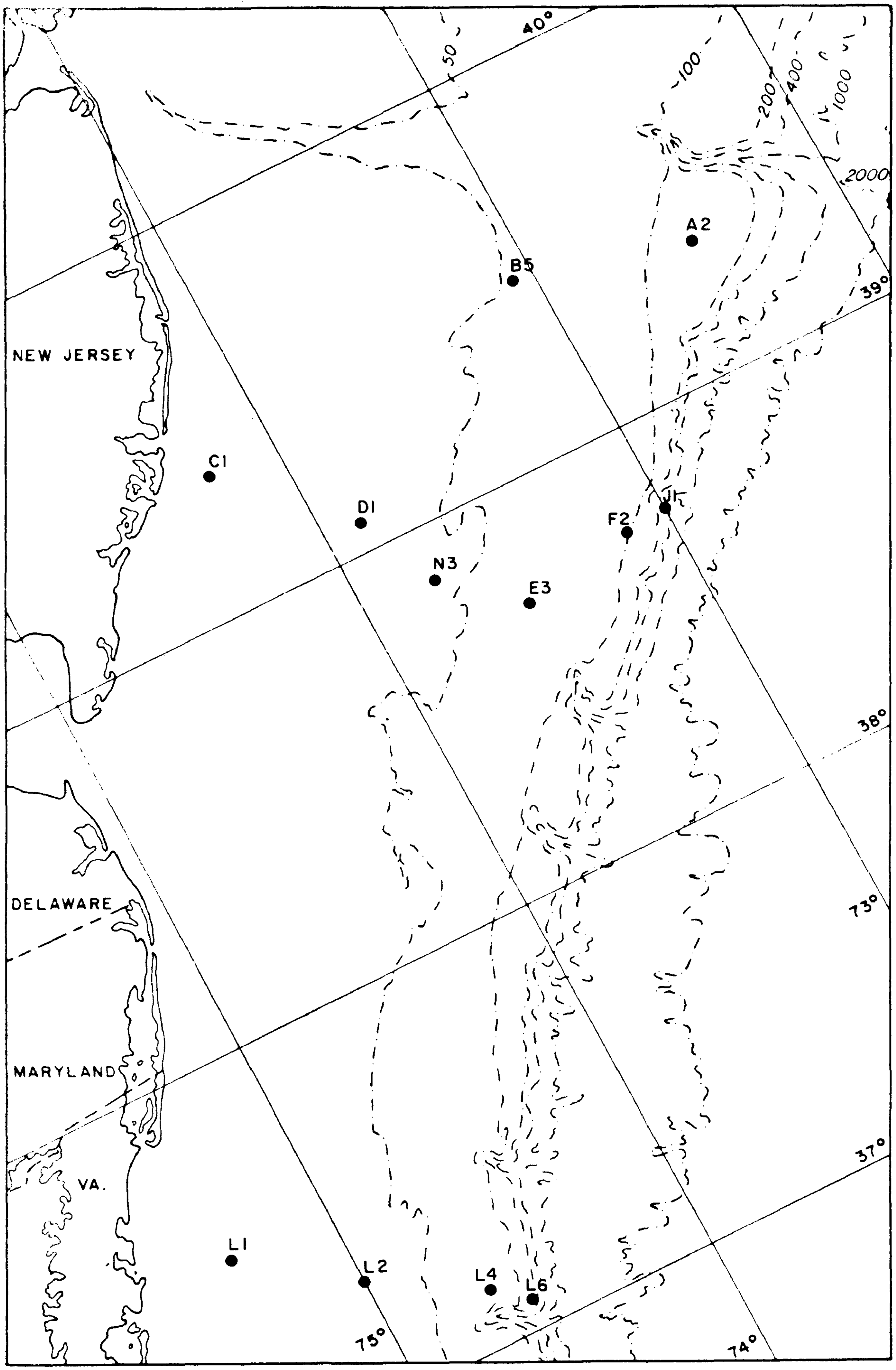
Sampling Design

Specimens were collected on five cruises from transects across the continental shelf (Fig. 1). The first cruise, designated 01W, began in October 1975 and was followed by cruises 02W in February 1976, 03W in May 1976, 04W in August 1976, and 05W in November 1976. During the first 4 cruises, a single transect with stations C1, D1, N3, E3, F2, and J1 was sampled. The transect extended southeasterly over the continental slope from a point 9km off Atlantic City, New Jersey. The stations ranged in depth from 12m at station C1 to over 300m at station J1. Six additional stations were added for cruise 05W positioned as follows: stations L1, L2, L4, and L6 were on a transect extending seaward from 28km off the southern portion of the Delmarva peninsula; stations B5 and A2 were located due east of station C1 near the 50m and 100m isobaths, respectively. The latitudinal and longitudinal coordinates as well as the depth at each station are summarized in Table 2.

Neuston Sampling

Surface fauna was sampled using a WHOI 1 meter neuston frame fitted with a 505μm mesh net, attached to a

FIGURE 1. Location of stations sampled for amphipods and other zooplankton, Middle Atlantic Bight, 1975-1976



40°
39°
38°
37°
73°
74°
75°
50
100
200
400
1000
2000
NEW JERSEY
DELAWARE
MARYLAND
VA.
A2
B5
C1
D1
N3
E3
F2
J1
L1
L2
L4
L6

TABLE 2

STATION LOCATIONS, DEPTH, AND DISTANCE OFFSHORE

STATION	LATITUDE (N)	LONGITUDE (W)	WATER DEPTH (M)	DISTANCE OFFSHORE (Km)
A2	39°23"	72°31"	130	143
B5	39°28"	73°03"	55	95
C1	39°22"	74°16"	12	9
D1	39°04"	73°53"	38	59
N3	38°52"	73°43"	46	111
E3	38°43"	73°32"	62	103
F2	38°43"	73°11"	107	126
J1	38°40"	73°05"	300	138
L1	37°30"	75°18"	26	28
L2	37°19"	74°57"	41	63
L4	37°09"	74°35"	97	97
L6	37°01"	74°33"	580	105

boom and fished abeam of the ship. This sampling device will be referred to as N505 in the text. The net was suspended outside the bow wave of the ship and was towed at a ship speed of two knots for 20 minutes. During cruises 01W--04W, each station was sampled eight times over a consecutive 24 hour period with tows every three hours until the entire six station transect was completed. During cruise 05W, eight consecutive neuston samples at three hour intervals were collected at stations B5, A2, C1, E3, J1, L1, L2, L4, and L6. At stations D1, N3, and F2, a single neuston tow was made between 2000 hours and midnight.

Bongo Sampling

The subsurface fauna was sampled with a 60cm opening/closing bongo frame (Oceans Instruments, Inc., San Diego, California). The frame was fitted with paired 505μm (B505) mesh nets for one tow, then with 202μm (B202) mesh nets for a second tow, at each station. Both bongo net tows were completed between 2000 hours and midnight. One side of the frame was fitted with a flow meter (General Oceanics, Miami, Florida) to measure volume filtered (m^3). During cruises 01W--04W, paired 505 and 202 tows were made at each of the six stations on the C1--J1 transect. Bongo tows were taken at all 12 stations during cruise 05W. At stations A2, B5, and E3, four bongo tows were made for each mesh size yielding a total of eight samples. The nets were lowered in the closed configuration to a sufficient depth to prevent surface contamination before opening. The gear was then lowered to near the bottom and raised in a stepped-oblique fashion. The nets were closed at approximately 1 meter depth before being brought through the surface layer to prevent contamination of the sample by surface fauna.

Sample Preservation

Once on board, the plankton sample was placed in a jar and sufficient concentrated buffered formaldehyde was added along with sea water to provide a 5% to 8% seawater formalin solution. Each sample was stored in a dark location to retard fading of pigmentation.

Hydrographics

Surface salinity and surface temperature were taken each time a neuston tow was made and STD (salinity-temperature-depth) casts were made for each bongo tow. The results of the surface hydrography are given in daily means.

Laboratory Processing of Collections

In the laboratory, the samples were sorted under an Olympus JM 100 darkfield scope. First, the samples were scanned in their entirety to remove any rare organisms before being subsampled using a VIMS plankton splitter

(Burrell et. al. 1974). Generally, aliquot size was adjusted to yield around 100 individuals usually between the 1/2 and 1/128 splits. Some collections with large numbers of hyperiidean amphipods required splitting to the 1/2048 fraction. The unused one half fraction from the original collection was retained for reference.

Identification of Hyperiideans

Hyperiideans were identified using the system revised by Bowman (1973) and Bowman and Gruner (1973). The latter publication updated the nomenclature of hyperiidean taxonomy. The former publication revised the taxonomy of the Hyperiidae. In addition, Bowman (1978) recently revised a portion of the Phrosinidae. The oxycephalids (Fage 1960) and the phronimids (Shih 1969) are the only other groups that have been revised recently. Consequently, the taxonomic literature of 18 families is fragmentary and scattered necessitating location of many original descriptions in the literature which at times was an arduous task taking many months of searching.

In many instances, appendages and mouth parts had to be dissected out and stained (Turtox CMC-S) to permit identification. In cases where only one specimen or only one specimen of each sex was available, I did not dissect out the various parts to identify the organisms. Reference collections at the National Museum of Natural History, Smithsonian Institution, Washington, D.C. were used for comparative purposes to aid identification.

A key to families based on the organisms from the present study is provided to facilitate identification of hyperiideans in the Middle Atlantic Bight (Fig. 2). Primary references are listed below the family name with the sources of original species descriptions.

The drawings in Figure 3 supplement the key. The drawings were made using an M5 Wild Stereomicroscope with a drawing tube attachment. The specimens were held in place with insect pins in a bed of modeling clay.

A reference collection is maintained by the Department of Planktology at the Virginia Institute of Marine Science.

FIGURE 2. Diagrammatic key to family for hyperiidean amphipods. UR--urosome, P--pereopod, A--antennae

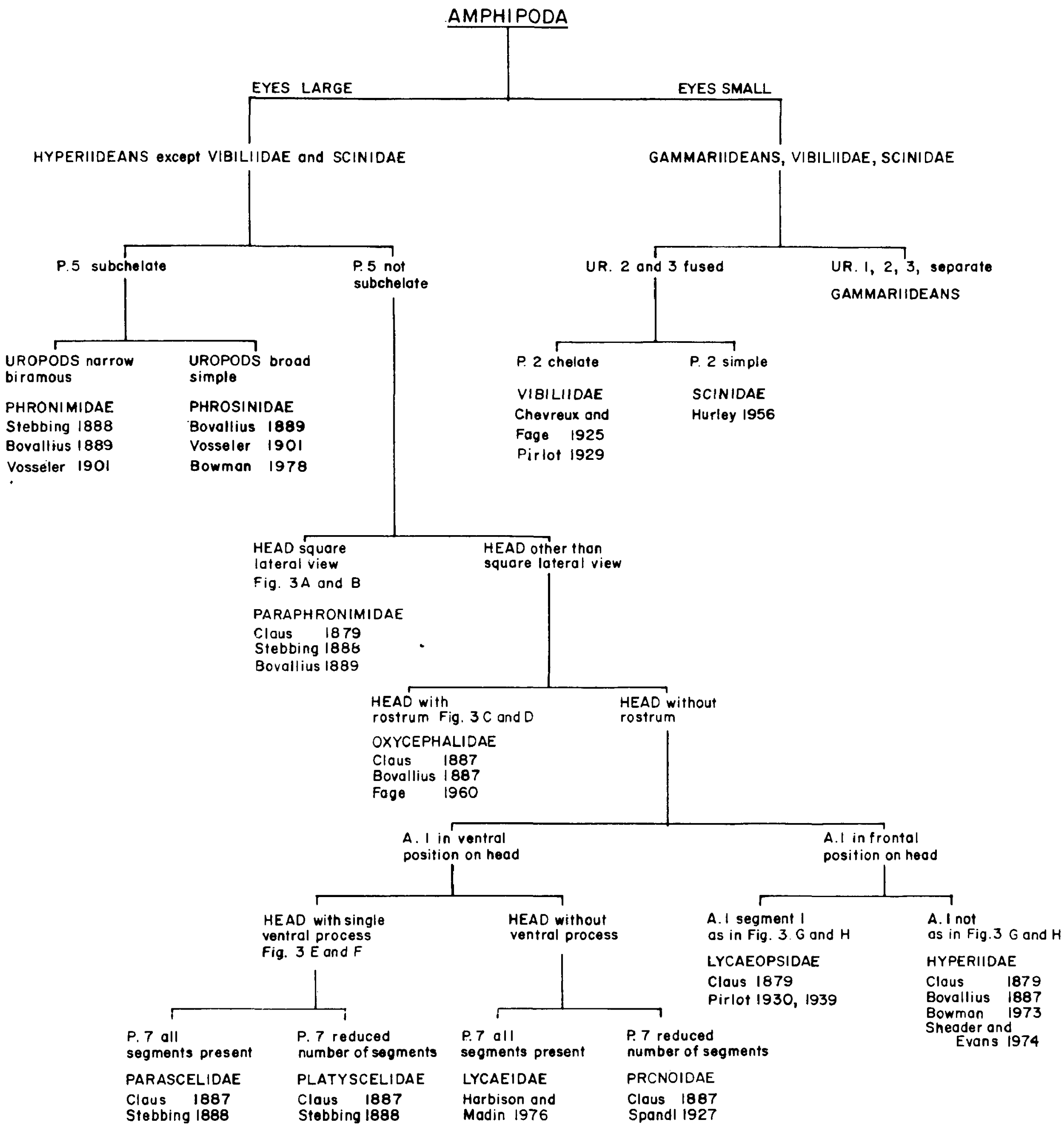
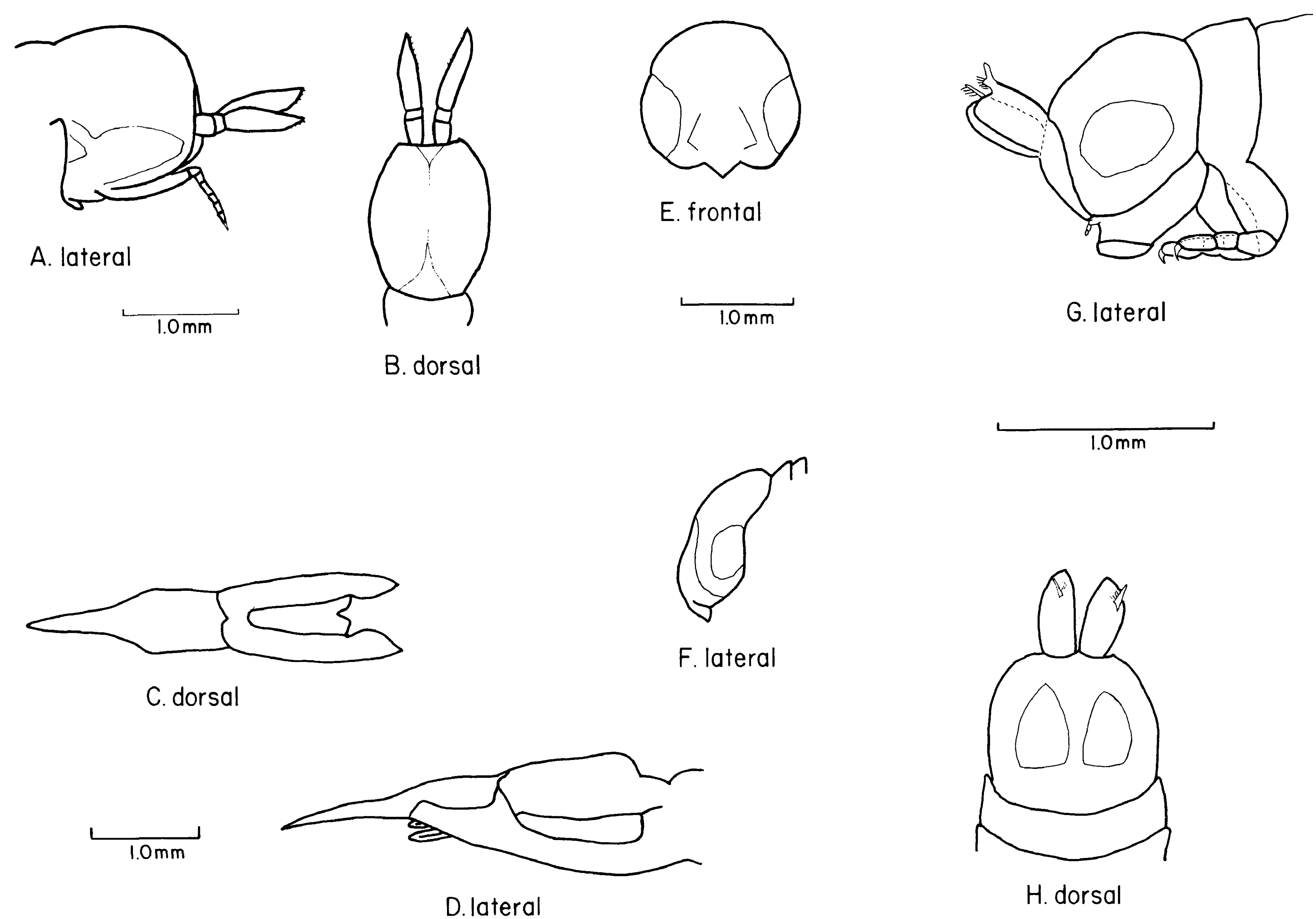

AMPHIPODA
EYES LARGE
EYES SMALL
HYPERIIDEANS except VIBILIIDAE and SCINIDAE
GAMMARIIDEANS, VIBILIIDAE, SCINIDAE
P.5 subchelate
P.5 not subchelate
UR. 2 and 3 fused
UR. 1, 2, 3, separate
GAMMARIIDEANS
UROPODS narrow biramous
PHRONIMIDAE
Stebbing 1888
Bovallius 1889
Vosseler 1901
UROPODS broad simple
PHROSINIDAE
Bovallius 1889
Vosseler 1901
Bowman 1978
P. 2 chelate
VIBILIIDAE
Chevreux and Fage 1925
Pirlot 1929
P. 2 simple
SCINIDAE
Hurley 1956
HEAD square lateral view Fig. 3A and B
PARAPHRONIMIDAE
Claus 1879
Stebbing 1888
Bovallius 1889
HEAD other than square lateral view
HEAD with rostrum Fig. 3 C and D
OXYCEPHALIDAE
Claus 1887
Bovallius 1887
Fage 1960
HEAD without rostrum
A. I in ventral position on head
A.I in frontal position on head
HEAD with single ventral process Fig. 3 E and F
HEAD without ventral process
A. I segment I as in Fig. 3 G and H
LYCAEOPSIDAE
Claus 1879
Pirlot 1930, 1939
A. I not as in Fig. 3 G and H
HYPERIIDAE
Claus 1879
Bovallius 1887
Bowman 1973
Sheader and Evans 1974
P. 7 all segments present
PARASCELIDAE
Claus 1887
Stebbing 1888
P. 7 reduced number of segments
PLATYSCELIDAE
Claus 1887
Stebbing 1888
P. 7 all segments present
LYCAEIDAE
Harbison and Madin 1976
P. 7 reduced number of segments
PRCNOIDAE
Claus 1887
Spandl 1927

FIGURE 3. Key characteristics of hyperiidean families referred to in Fig. 2


A. lateral
1.0mm
B. dorsal
E. frontal
1.0mm
G. lateral
1.0mm
C. dorsal
F. lateral
H. dorsal
1.0mm
D. lateral

RESULTS

Hydrographic Conditions

The area of the Middle Atlantic Bight sampled during this study is within the transition zone between the boreal and subtropical regions of the western North Atlantic. This transition zone is characterized by a wide range in seasonal temperatures. The average sea surface temperature followed three areal gradients which are indicative of the seasons on the C1--J1 transect. In the winter, the surface temperature ranged from 2.6°C to 9.7°C and increased with distance offshore. In the spring, the surface temperature ranged from 15.3°C to 17.0°C and decreased with distance offshore. During the summer and fall, the temperature ranged from 20.6°C to 22.3°C and 16.3°C to 20.2°C respectively, with a temperature decrease from C1 to the midshelf stations, then an increase out to J1.

There are also distinct differences in the temperature conditions between the transects off New Jersey and those off Virginia. The two northern transects were relatively similar in temperature characteristics during November 1976, while the southern transect was distinctly warmer. For instance, stations B5, E3, and L4 were located approximately the same distance offshore and the average surface temperature was 10.4°C at B5, 11.0°C at E3, and 13.9°C at L4 in November 1976.

Salinity of surface waters during October 1975 ranged from 30.5ppt at station C1 to 34.7ppt at station J1 (Table 3). This was the widest range of average sea surface salinity observed during the study. A similar range was apparent during the February 1976 cruise, but in subsequent cruises, the shelfwide variation in salinity was considerably reduced. During May 1976, the salinity range from station C1 to station J1 was 1.3ppt, the smallest of all five cruises.

General Hyperiidean Contribution

A total of 23,222 hyperiidean amphipods was examined from the 267 neuston and 90 bongo samples taken during the five cruises. The surface hyperiideans of cruise 01W totaled 322,767 and represented 19.6% of the surface fauna sampled from stations C1--J1 (Table 4). The center of amphipod concentration was located at stations D1, N3, and E3, where the hyperiideans clearly dominated the surface fauna. The hyperiideans ranged from 64.5% at E3 to a high of 83.7% at D1. From this peak of total individuals during 01W, the total abundance declined to 64,067 in February 1976. Even with the decline in abundance, the percent contribution to total zooplankton remained relatively stable at 17.8%. The center of concentration was at stations N3 and E3. The hyperiideans declined to the lowest abundance in May

TABLE 3

AVERAGE SEA SURFACE TEMPERATURE (°C) AND AVERAGE SEA SURFACE SALINITY (PPT)* AT 24-HOUR STATIONS

Station	October 1975		February 1976		May 1976		August 1976		Nobember 1976	
	T°C	S(ppt)	T°C	S(ppt)	T°C	S(ppt)	T°C	S(ppt)	T°C	S(ppt)
B5									10.4	33.6
A2									12.5	34.8
C1	17.5	30.5	2.6	30.3	17.0	32.0	20.6	31.8	9.4	32.4
D1	17.1	32.3	3.9	32.0	16.6	32.1	22.3	32.4		
N3	16.7	32.8	6.3	32.8	16.6	32.1	21.4	32.1		
E3	16.3	32.8	8.4	33.8	16.6	32.0	21.6	33.6	11.0	34.2
F2	16.9	33.6	9.4	34.5	15.3	32.5	21.5	34.1		
J1	20.2	34.7	9.7	34.4	15.6	33.3	21.8	34.0	12.1	34.4
L1									15.4	33.2
L2									12.6	33.9
L4									13.9	34.8
L6									14.0	34.9

*ppt--parts per thousand

TABLE 4

SURFACE ABUNDANCE (8 STANDARD 20 MINUTE NEUSTON TOWS) AND PERCENT CONTRIBUTION OF HYPERIIDEANS TO TOTAL ZOOPLANKTON, BY STATION, FOR CRUISES 01W--04W

Station	Oct 75			Feb 76			May 76			Aug 76		
	Zoop.	Hyp.	%	Zoop.	Hyp.	%	Zoop.	Hyp.	%	Zoop.	Hyp.	%
C1	1029271	42	0.004	16186	3	0.01	134543	35	0.02	2213279	2285	0.1
D1	187681	157170	83.7	20926	738	3.5	118739	5	0.004	529651	47280	8.9
N3	87530	62977	71.9	55745	12031	21.6	149990	7528	5.0	188094	14871	7.9
E3	145714	93970	64.5	87457	42540	48.6	167525	6843	4.1	80181	4193	5.2
F2	122907	384	0.3	42569	2295	5.4	189722	14614	7.7	46297	3306	7.1
J1	77815	8224	10.6	136930	6460	4.7	73830	26580	36.0	52089	6027	11.6
Totals	1650918	322767	19.6	359813	64067	17.8	834349	55600	6.7	3109591	77962	2.5

1976 with 55,600 total amphipods collected representing 6.7% of the total fauna. During cruise 03W, the center of abundance had shifted to stations F2 and J1. In August 1976, the surface abundance of hyperiideans increased substantially to 77,962 and the center of abundance was located at stations C1 and D1, but the percent contribution was at the lowest point (2.5%). At station C1, the abundance had been negligible with only 42, 3, and 35 hyperiideans collected during cruises 01W, 02W, and 03W respectively. During cruise 04W, 2285 individuals were collected at C1, but representing a mere 0.1% of the total surface zooplankton collected at that station. Hyperiideans taken during cruise 04W at station C1 were primarily a warm water species which was absent in cruises 02W and 03W.

The hyperiideans were much less important in the subsurface fauna (Table 5). There were only a few samples which contained hyperiideans in any substantial numbers. For instance, the bongo 505 from station D1--01W and bongo 505 from N3--04W showed hyperiideans contributing 40% and 14% respectively. In the rest of the samples, the hyperiideans never exceeded 8%. The subsurface assemblages followed a similar seasonal abundance pattern as that which was evident in the surface fauna. The highest number/volume sampled, $4.34/m^3$, was observed during cruise 01W. Abundance declined steadily through cruises 02W, 03W, and 04W with values of $2.3/m^3$, $1.2/m^3$, and

TABLE 5

PERCENT HYPERIIDEANS IN TOTAL ZOOPLANKTON (BASED ON NUMBERS/M^3) IN SUBSURFACE SAMPLES FROM EACH STATION DURING CRUISES 01W TO 04W

Station	Gear	Cruise Oct 75	Feb 76	May 76	Aug 76
C1	B505			0.0	
	B202			0.0	
D1	B505	40.0	0.0		6.6
	B202	6.1	0.1	0.0	2.5
N3	B505	2.5	4.2	0.7	14.2
	B202	1.1	0.4		7.1
E3	B505	1.4	0.0	0.9	0.2
	B202	0.1	0.3	0.0	3.4
F2	B505	0.8	0.0	0.1	5.9
	B202	0.3	0.1	0.0	0.4
J1	B505	4.2	0.0	0.7	1.1
	B202	0.4	0.0	0.1	0.1

0.0--less than 0.05%

$0.4/m^3$ respectively. On a seasonal basis, the center of concentration shifted from station D1 during 01W to station N3 during 02W. Station E3 had the greatest number/volume sampled during 03W after which the center moved back inshore during 04W (Table 6).

The frequency of hyperiidean occurrence in the surface and subsurface samples provided an additional measure of their importance to the assemblages. The suborder occurred in 85.4% of all subsurface samples from cruises 01W--04W (Table 6), with station C1 lacking the hyperiideans in five of the eight samples. In the surface fauna, there was a frequency of occurrence of 77.6% for cruises 01W--04W (Table 7). Also included in that table is frequency of occurrence for each station. During cruise 03W, the lowest total frequency of occurrence, 50%, was observed. During cruise 04W, hyperiideans were present at all stations, although the abundance was not at its peak.

Seasonal changes in general hyperiidean abundance were evident during cruises 01W--04W. Parathemisto gaudichaudi and Lestrigonus bengalensis were clearly the dominant hyperiidean species in surface and subsurface samples, contributing over 99% to the total number of hyperiideans collected. P. gaudichaudi comprised 98% of the hyperiideans sampled during cruise 01W and 99% in cruises 02W, 03W, and 05W. The relative contribution of P. gaudichaudi decreased to 13.8% during 04W and L. bengalensis contributed 85.9%. Consequently, any trends

TABLE 6

NUMBER OF INDIVIDUALS PER M^3 IN SUBSURFACE SAMPLES FROM EACH STATION DURING CRUISES 01W TO 05W

Station	Gear	Cruise				
		Oct 75	Feb 76	May 76	Aug 76	Nov 76
C1	B505	NC	NC	0.01	0.34	NC
	B202	NC	NC	0.00	NC	0.01
D1	B505	46.25	0.38	NC	12.35	45.62
	B202	67.42	0.23	0.00	14.85	76.88
N3	B505	1.07	10.71	1.29	13.39	71.14
	B202	11.29	30.07	NC	25.26	41.34
E3	B505	2.50	1.20	2.46	0.21	15.40
	B202	3.84	2.57	3.15	5.38	18.78
F2	B505	0.10	1.23	1.74	3.24	0.55
	B202	0.17	0.96	1.48	1.29	0.33
J1	B505	0.04	0.01	0.50	0.23	0.17
	B202	0.01	0.00	0.23	0.15	0.89
No. of samples with hyperiideans		10	10	10	11	11

NC--no species collected
0.00--less than 0.005 individuals/m^3 but at least one individual

TABLE 7

SURFACE FREQUENCY OF OCCURRENCE OF HYPERIIDEANS (%) AND NUMBER OF SAMPLES CONTAINING HYPERIIDEANS AT EACH STATION FOR CRUISES 01W to 05W

Station	Oct 75		Feb 76		May 76		Aug 76		Nov 76	
	%	No.	%	No.	%	No.	%	No.	%	No.
C1	37.5	3	12.5	1	37.5	3	100.0	8	50.0	4
D1	100.0	8	62.5	5	37.5	3	100.0	8	*	
N3	100.0	8	87.5	7	50.0	4	100.0	8	*	
E3	100.0	8	100.0	8	50.0	4	100.0	8	100.0	8
F2	75.0	6	87.5	7	75.0	6	100.0	8	*	
J1	100.0	8	100.0	8	50.0	4	100.0	8	100.0	8
Cruise Total (C1-J1)	85.4	41	75.0	36	50.0	24	100.0	48	83.3	20
B5									100.0	8
A2									100.0	8
L1	-		-		-		-		100.0	8
L2	-		-		-		-		100.0	8
L4	-		-		-		-		100.0	8
L6	-		-		-		-		100.0	8

*only one sample taken
-no samples taken

in total hyperiidean abundance and frequency of occurrence were governed by the presence of these two species. A more detailed analysis is provided in the section dealing with individual species.

General Species Composition

A total of 63 species of the suborder Hyperiidea were collected from the continental shelf waters of the Middle Atlantic Bight, representing 12 families (Table 8). Of that total, 20 species occurred only in bongo samples and 12 occurred only in neuston samples. There were 51 species found in the subsurface assemblages and 43 species in the surface assemblages.

Some seasonal cycles were evident in species occurrence. During winter and spring, the hyperiideans were virtually monospecific in the surface waters (Table 9), with the only exceptions being at stations F2 of 02W and J1 of 03W. From the spring and winter low, the number of species increased to a maximum in the summer and then declined substantially in the fall. The number of hyperiidean species in the subsurface water followed a similar pattern. There were very few species present in the winter samples, virtual monospecificity of hyperiideans in the spring, a maximum number of species in the summer, and a substantial decline in species in the fall. *P. gaudichaudi* was the only species present in the study area throughout the year.

The transshelf distribution of species in the surface

TABLE 8

CHECKLIST OF FAMILIES AND SPECIES

	Gear N5	Gear B2	Gear B5
Suborder Hyperiidea			
Infraorder Physosomata			
Family Scinidae			
Scina curvidactyla Chevreux, 1914	X		
Scina damasii Pirlot, 1929	X		
Scina stebbingi Chevreux, 1914	X		
Scina stenopus Stebbing, 1895		X	X
Family Vibiliidae			
Vibilia armata Bovallius, 1887	X		X
Family Paraphronimidae			
Paraphronima gracilis Claus, 1879		X	X
Infraorder Physocephalata			
Family Hyperiidae			
Hyperia galba (Montagu, 1813)		X	
Hyperia medusarum (Miller, 1776)		X	
Hyperietta stephenseni Bowman, 1973	X	X	
Hyperietta vosseleri (Stebbing, 1904)	X	X	X
Hyperoche mediterranea Senna, 1906	X		
Iulopis loveni Bovallius, 1887	X		
Lestrigonus bengalensis Giles, 1887	X	X	X
Lestrigonus crucipes (Bovallius, 1889)	X	X	
Lestrigonus latissimus (Bovallius, 1889)	X	X	
Lestrigonus schizogeneios (Stebbing, 1888)	X	X	X
Parathemisto gaudichaudi (Guerin, 1825)	X	X	X
Phronimopsis spinifera Claus, 1879	X	X	
Themistella fusca (Dana, 1852)	X		X
Family Phronimidae			
Phronima atlantica Guerin, 1836	X	X	X
Phronima colletti Bovallius, 1887	X		X
Phronima pacifica Streets, 1877			X
Phronima sedentaria (Forskal, 1775)	X	X	
Phronimella elongata (Claus, 1862)	X	X	X

Table 8 continued

	Gear		
	N5	B2	B5
Family Phrosinidae			
Anchylomera blossevillii Milne-Edwards, 1830	X	X	X
Phrosina semilunata Risso, 1822	X	X	X
Primno brevidens Bowman, 1978		X	X
Primno johnsoni Bowman, 1978		X	X
Primno latreillei Stebbing, 1888		X	X
Primno juv.		X	X
Family Lycaeopsidae			
Lycaeopsis neglecta Pirlot, 1929	X	X	X
Lycaeopsis themistoides Claus, 1879	X		X
Lycaeopsis zamboangae Claus, 1879	X	X	X
Family Pronoidae			
Eupronoe armata Claus, 1879b	X	X	X
Eupronoe minuta Claus, 1879b	X	X	
Paralycaea sp. Claus, 1879b	X		
Sympronoe parva Claus, 1879b	X		X
Family Lycaeidae			
Brachyscelus crusculum Bate, 1861	X	X	X
Brachyscelus macrocephalus Stephensen, 1925	X		
Brachyscelus rapacoides Stephensen, 1925	X		X
Lycaea bovallioides Stephensen, 1925			X
Lycaea pulex Marion, 1874	X	X	
Thamneus platyrrhynchus Stebbing, 1888	X		
Tryphana malmi Boeck, 1871	X		X
Family Oxycephalidae			
Calamorhynchus pellucidus Streets, 1878			X
Cranocephalus sp. (Streets, 1878)			X
Glossocephalus milne-edwardsi Bovallius, 1887	X		
Leptocotis tenuirostris (Claus), 1871			X
Oxycephalus clausi Bovallius, 1887		X	X
Oxycephalus piscator Milne-Edwards, 1880	X	X	
Rhabdosoma armatum (Milne-Edwards), 1840			X
Rhabdosoma whitei Bate, 1862		X	X
Streetsia challengeri Stebbing, 1888		X	
Streetsia mindanaonis (Stebbing), 1888		X	
Streetsia porcella (Claus), 1879			X
Streetsia steenstrupi Bovallius 1887		X	X
Tullbergella cuspidata Bovallius, 1887		X	

Table 8 continued

	Gear		
	N5	B2	B5
Family Platyscelidae			
Amphithyrus sculpturatus Claus, 1879b	X		X
Hemityphis rapax (Milne-Edwards, 1830)	X	X	X
Paratyphis parvus Claus, 1887	X	X	X
Platyscelus serratulus Stebbing, 1888	X	X	X
Tetrathyrus forcipatus Claus, 1879b	X	X	X
Family Parascelidae			
Thyropus sphaeroma (Claus, 1879)	X	X	X
Thyropus edwardsi (Claus 1879)	X		

N5--Neuston 505μm
B2--bongo 202μm
B5--bongo 505μm

TABLE 9

NUMBER OF HYPERIIDEAN SPECIES TAKEN AT EACH STATION IN THE SURFACE LAYER (SUR) AND SUBSURFACE WATERS (SUB)

Station	Cruise									
	Oct 75		Feb 76		May 76		Aug 76		Nov 76	
	Sur	Sub	Sur	Sub	Sur	Sub	Sur	Sub	Sur	Sub
B5									1	1
A2									3	11
C1	1	0	1	0	1	1	4	1	1	1
D1	1	1	1	2	1	1	9	3	*	1
N3	5	1	1	3	1	1	4	4	*	1
E3	1	1	1	2	1	1	11	26	3	4
F2	2	1	2	3	1	1	19	21	*	10
J1	6	13	1	1	5	1	26	32	2	8
L1									4	2
L2									9	4
L4									9	8
L6									8	11

*only one sample taken

and subsurface assemblages provides an additional aspect of hyperiidean occurrence. In the fall, (except station J1), winter and spring, the number of species taken in the subsurface fauna across the shelf was low. Only during cruise 04W did any substantial number of species appear. At that time, from station E3 seaward, the number of species in the subsurface waters exceeded 20 at each station. Substantially fewer species were taken during 05W, even though an increase in the number of species did occur at the outer shelf. The same condition was present in the surface assemblages. A detailed breakdown of the species taken at each station during cruises 01W--04W is given in Table 10 for the subsurface collections and Table 11 for the surface collections. _P_. _gaudichaudi_ and _L_. _bengalensis_ were the only two species taken at every station on the transect in both the surface and subsurface samples.

The station distribution during cruise 05W afforded the opportunity to compare hyperiideans from two different latitudinal areas. The northern area contained stations B5, A2, C1, D1, N3, E3, F2, and J1. The southern section was composed of stations L1, L2, L4, and L6. The subsurface fauna of both areas was characterized by a substantial increase in the number of species at all stations near the shelf edge (A2, F2, J1, L4, and L6)(Table 12). At station A2, a total of 12 species was collected in all eight replicate tows with eight species being the highest

TABLE 10

SPECIES OCCURRENCE IN THE SUBSURFACE FAUNA (CRUISES 01W--04W).

Species	C1				D1				N3				E3				F2				J1			
	F	W	S	Su	F	W	S	Su	F	W	S	Su	F	W	S	Su	F	W	S	Su	F	W	S	Su
Hyperia galba						X																		
Hyperia medusarum																				X				
Hyperietta stephenseni																					X			
Hyperietta vosseleri																X				X	X			
Lestrigonus bengalensis				X				X				X				X				X	X			X
Lestrigonus crucipes																								X
Lestrigonus latissimus																								X
Lestrigonus schizogeneios																				X	X			X
Parathemisto gaudichaudi			X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Brachyscelus crusculum																				X				X
Brachyscelus rapacoides																X								
Lycaea bovallioides																					X			
Lycaea pulex																								X
Tryphana malmi																								X
Lycaeopsis neglecta																X								X
Lycaeopsis themistoides																X								X
Lycaeopsis zamboangae																X				X				X
Calamorhynchus pellucidus																X								X
Cranocephalus sp.																								X
Leptocotis tenuirostris																X								X
Oxycephalus clausi																X				X				
Oxycephalus piscator																								X
Rhabdosoma armata																X								

Table 10 continued

Species	C1				D1				N3				E3				F2				J1			
	F	W	S	Su	F	W	S	Su	F	W	S	Su	F	W	S	Su	F	W	S	Su	F	W	S	Su
Rhabdosoma whitei																				X				X
Streetsia mindanaonis																				X				
Streetsia porcella																X								X
Streetsia steenstrupi																					X			X
Tullbergella cuspidata																				X				
Paraphronima gracilis														X				X						X
Thyropus sphaeroma																X								X
Phronima atlantica																X				X	X			
Phronima colletti																X								
Phronima pacifica																X								
Phronima sedentaria										X								X			X			
Phronimella elongata												X				X				X	X			X
Anchylomera blossevillii																X				X	X			X
Phrosina semilunata																X				X	X			X
Primno brevidens																X					X			
Primno johnsoni												X												
Primno latreillei																X								X
Primno sp.									X											X				
Hemityphis rapax																X				X				X
Paratyphis parvus																X				X				X
Platyscelus serratulus																X				X				X
Tetrathyrus forcipatus							X									X				X				X
Eupronoe armata																X				X				X
Eupronoe minuta																X				X				X

Table 10 continued

Species	C1				D1				N3				E3				F2				J1			
	F	W	S	Su	F	W	S	Su	F	W	S	Su	F	W	S	Su	F	W	S	Su	F	W	S	Su
Sympronoe parva																								X
Vibilia armata																								X
Scina stebbingi																							X	

F--cruise 01W
W--cruise 02W
S--cruise 03W
Su--cruise 04W

TABLE 11

SPECIES OCCURRENCE IN THE SURFACE WATERS (CRUISES 01W--04W) BY STATION

Species	C1				D1				N3				E3				F2				J1			
	F	W	S	Su	F	W	S	Su	F	W	S	Su	F	W	S	Su	F	W	S	Su	F	W	S	Su
Hyperietta stephenseni								X				X												
Hyperietta vosseleri									X															
Hyperoche mediterranea				X				X																
Lestrigonus bengalensis				X				X				X				X	X			X	X			X
Lestrigonus crucipes									X															
Lestrigonus latissimus				X					X											X				X
Lestrigonus schizogeneios									X							X				X				X
Parathemisto gaudichaudi	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Brachyscelus crusculum																				X	X			X
Brachyscelus macrocephalus																								X
Brachyscelus rapacoides																				X				
Lycaea pulex																X								X
Tryphana malmi																		X						
Lycaeopsis neglecta																								X
Lycaeopsis themistoides								X								X				X				X
Lycaeopsis zamboangae												X				X				X				X
Glossocephalus milne-edwardsi								X																
Oxycephalus piscator																				X				X
Thyropus sphaeroma								X								X				X				X
Thyropus edwardsi								X												X				X

Table 11 continued

Species	C1				D1				N3				E3				F2				J1			
	F	W	S	Su	F	W	S	Su	F	W	S	Su	F	W	S	Su	F	W	S	Su	F	W	S	Su
Phronima atlantica																				X				X
Phronimella elongata																								X
Anchylomera blossevillii																				X	X			X
Phrosina semilunata																					X			X
Amphithyrus sculpturatus																				X				X
Hemityphis rapax																X				X				X
Paratyphis parvus																X				X				X
Platyscelus serratulus																				X				X
Tetrathyrus forcipatus								X								X				X				X
Eupronoe armata																				X				X
Eupronoe minuta																X				X				X
Paralycaea sp.																								X
Sympronoe parva																								X
Vibilia armata																								X
Scina curvidactyla																							X	
Scina damasii																							X	
Scina stebbingi																							X	

F--cruise 01W
W--cruise 02W
S--cruise 03W
Su--cruise 04W

TABLE 12

SPECIES OCCURRENCE IN SUBSURFACE
WATERS OF CRUISE 05W BY STATION

Species	L1	L2	L4	L6	C1	D1	N3	E3	F2	J1	B5	A2
Hyperietta vosseleri				X					X			
Lestrigonus bengalensis	X		X	X				X				X
Parathemisto gaudichaudi	X		X	X	X	X	X	X	X	X	X	X
Phronimopsis spinifera				X						X		
Themistella fusca			X									
Tryphana malmi									X			
Lycaeopsis zamboangae		X										
Leptocotis tenuirostris												X
Rhabdosoma whitei									X			
Streetsia challengeri												X
Streetsia steenstrupi				X								
Paraphronima gracilis				X					X			X
Phronima atlantica		X	X	X					X	X		X
Phronima colletti				X								
Phronima pacifica			X									
Phronima sedentaria										X		
Phronimella elongata		X						X	X			
Anchylomera blossevillii												X
Phrosina semilunata			X	X								X
Primno brevidens								X		X		X
Primno johnsoni									X			X
Amphithyrus sculpturatus												X
Hemityphis rapax										X		
Paratyphis parvus									X			
Tetrathyrus forcipatus		X	X									
Eupronoe armata			X									
Eupronoe minuta				X					X	X		X
Scina stenopus				X						X		
Total Species	2	4	8	11	1	1	1	4	10	8	1	12

number for any one tow (Table 13). At stations F2 and J1, there were ten and eight species respectively. On the southern transect, a similar number of species was collected at the outer shelf stations with eight found at L4 and 11 found at L6. Eleven species occurred in both northern and southern sectors.

Similarity of fauna was not as evident in the surface waters with only five species occurring in both northern and southern regions (Table 14). In fact, only two species, both from the family Hyperiidae showed any consistent occurrence in both regions. On the southern transect, several warm water species appeared which were not collected previously, namely *Iulopis loveni*, *Themistella fusca*, and *Thamneus platyrrhynchus*.

Individual Species Occurrences

Seasonal occurrence (based on cruises 01W--04W) and transshelf variations of individual species are presented in the section below. A species is discussed if it met either of the following criteria: 1. Neuston--any species that occurred in at least 25% of the samples (2 of 8) at any given station; 2. Bongo--any species that occurred in 25% of the samples (3 of 12) during any particular cruise.

Family Hyperiidae Dana, 1852

Hyperietta stephenseni Bowman, 1973

This species was not previously reported from the

TABLE 13

REPLICATE BONGO TOWS, NUMBER OF SPECIES IN EACH SAMPLE, TOTAL NUMBER OF SPECIES FOR EACH GEAR AT THE STATION

Station	B505 Per Sample	Total Species For Gear	B202 Per Sample	Total Species For Gear
B5	1	2	1	1
	2		1	
	1		1	
	1		1	
A2	3	8	6	12
	6		8	
	2		7	
	4		1	
E3	2	3	1	2
	1		1	
	2		2	
	1		2	

TABLE 14

SPECIES OCCURRENCE IN SURFACE WATERS OF CRUISE 05W BY STATION

Species	L1	L2	L4	L6	C1	D1	N3	E3	F2	J1	B5	A2
Iulopis loveni		X										
Lestrigonus bengalensis	X	X	X	X		X		X				X
Lestrigonus crucipes									X			
Lestrigonus schizogeneios		X										
Parathemisto gaudichaudi	X	X	X	X	X	X	X	X	X	X	X	X
Phronimopsis spinifera				X								X
Themistella fusca	X	X	X									
Brachyscelus macrocephalus		X										
Thamneus platyrrhynchus				X								
Lycaeopsis neglecta	X					X						
Lycaeopsis zamboangae		X										
Oxycephalus clausi				X								
Phronima atlantica			X					X				
Phronima colletti		X										
Phronima sedentaria										X		
Anchylomera blossevillii			X	X								
Hemityphis rapax			X									
Tetrathyrus forcipatus		X	X	X								
Eupronoe armata			X									
Eupronoe minuta			X	X								
Total Species	4	9	9	8	1	3	1	3	2	2	1	3

Middle Atlantic Bight. This species occurred in 2 of 8 neuston samples at station N3--04W and 1 sample at D1--04W. No individuals were taken in the bongo samples. This species was of relatively low abundance and infrequent in occurrence for any reliable conclusions to be drawn.

Hyperoche mediterranea Senna, 1906

There is no previous record of this species in the Middle Atlantic Bight. During the present study, *H. mediterranea* was found at the nearshore stations (C1, D1) during cruise 04W. A total of 29 individuals occurred in 4 of 8 neuston tows at D1--04W and 1 neuston tow at C1--04W. No specimens were collected in the bongo samples.

Bigelow (1926) listed three species of *Hyperoche* namely *H. abyssorum*, *H. broyeri*, and *H. tauriformis* which are synonomous with *H. medusarum* (T. E. Bowman, personal communication). In that respect, the species *H. medusarum* was found in water up to 80 meters deep during November and February. In contrast, *H. mediterranea* of the present study was taken in August and in water up to 40 meters deep.

Lestrigonus bengalensis Giles, 1887

This species was not previously reported in the Middle Atlantic Bight. During cruise 04W, this species dominated the surface assemblage, contributing 86% to the total number of hyperiideans sampled. The greatest concentrations for *L. bengalensis* were found at station D1

(Table 15). Here, the highest number of individuals per tow was taken in the neuston and the greatest number of individuals per cubic meter was taken in the bongo samples. However, at station C1--04W, this species provided the greatest number of hyperiideans taken at this station during any of the five cruises. The frequency of occurrence in the surface waters was 100% for the three inshore stations and remained above 62% at the three outer shelf stations. The abundance of this species in the subsurface waters decreased very rapidly seaward of station N3. The surface diel distributional patterns are presented in Figure 4. The only consistent pattern occurred at stations D1, N3, and E3 where the surface numbers increased to a maximum between 0000 hours and 0400 hours.

During 05W, _L. bengalensis_ represented 99% of the surface hyperiideans at station L1 and 100% frequency of occurrence in the neuston samples. At station L2, the frequency of occurrence declined to 62.5% and represented 6.7% of the hyperiideans. _L. bengalensis_ occurred in 50% of the neuston samples at station L4 and contributed less than 1% of the hyperiideans. At station L6, this species occurred in one neuston sample. In the subsurface samples of the L transect, this species never exceeded 5% of the hyperiideans in any sample. On the northern transects, _L. bengalensis_ occurred in one neuston sample at the following stations: A2, B5, and E3. In addition,

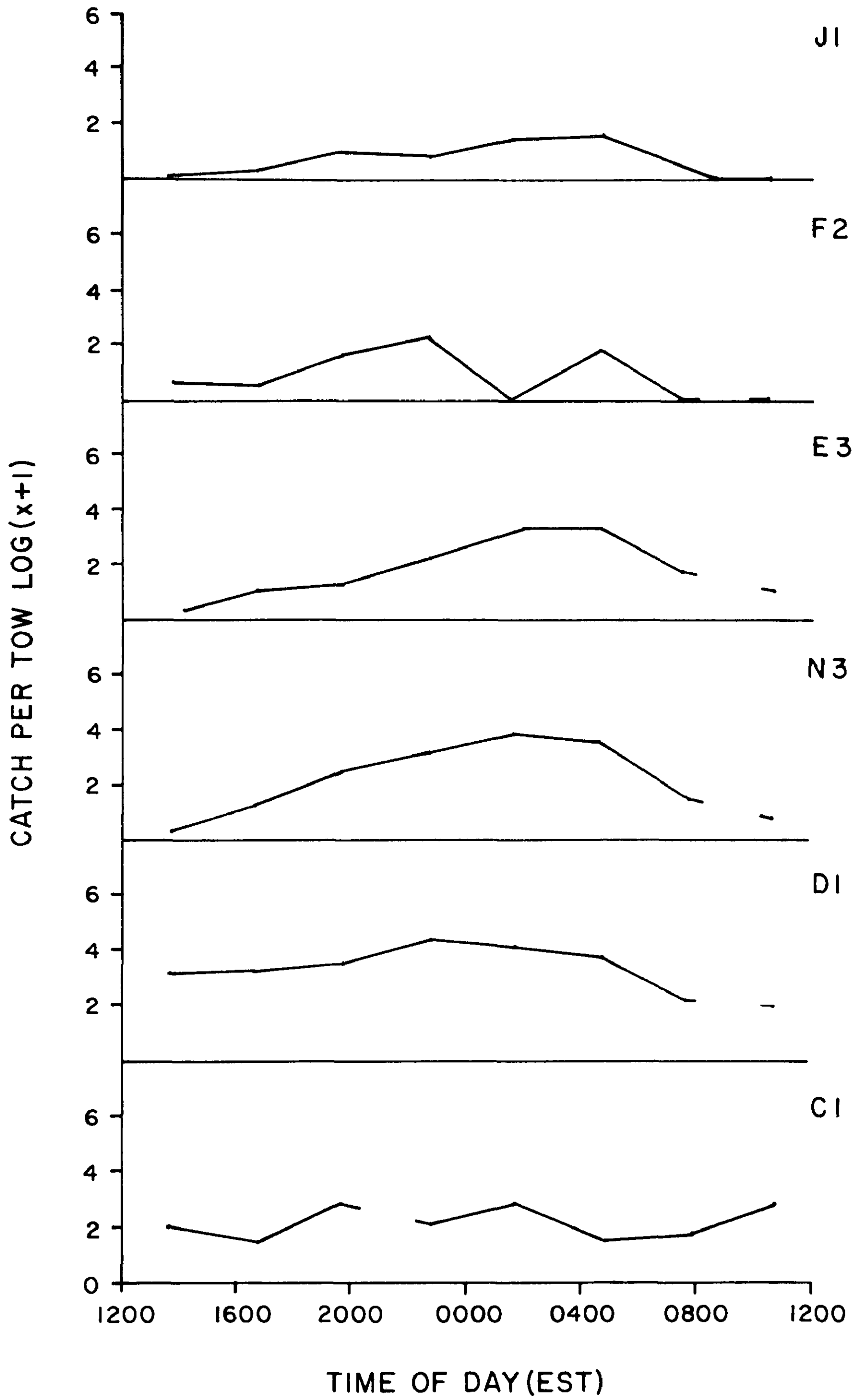
TABLE 15

SURFACE FREQUENCY OF OCCURRENCE FOR LESTRIGONUS BENGALENSIS AS MEAN NUMBERS PER TOW FOR 8 STANDARD NEUSTON TOWS, AS NUMBER PER VOLUME FILTERED FOR BONGO SAMPLES, AND AS PERCENT OF HYPERIIDEANS AT STATION FOR CRUISE 04W

	Neuston			Bongo		
Station	Mean No./tows	% C	% F	Mean No./m^3	total indiv.	% C
C1	436.3	99.5	100	0.34	84	100
D1	5983.4	99.1	100	6.72	5056	47
N3	1994.8	81.9	100	1.26	928	7.2
E3	469.4	85.8	88	0.07	83	2.8
F2	31.4	7.6	63	0.01	12	-
J1	6.5	0.1	71		6	1.9

-negligible
% C--percent contribution to total hyperiideans at station by gear
% F--frequency of occurrence as percent

FIGURE 4. Diel migratory pattern of *L. bengalensis* for 04W based on eight consecutive neuston samples at each station



J1
F2
E3
N3
D1
C1
CATCH PER TOW LOG (x+1)
0
2
4
6
1200
1600
2000
0000
0400
0800
1200
TIME OF DAY (EST)

one bongo sample from station A2 and one bongo sample from E3 contained _L_. _bengalensis_.

This was the second most important species found throughout the study.

Lestrigonus schizogeneios (Stebbing) 1888

This species was not previously recorded from the Middle Atlantic Bight. This species was taken in two surface samples at E3--04W, one surface sample at F2--04W, and one surface sample at J1--04W. Additionally, it was present in one subsurface sample at stations F2--04W and J1--04W. During 05W, this species occurred in one neuston sample at L2. The total number for all samples was relatively small at less than 100 individuals.

Parathemisto gaudichaudi (Guerin, 1825)

Several previous records of this species exist from the area of the present study (Table 1). A great deal of discussion has revolved around the taxonomy of this particular species. Two distinct forms exist which, in the past, were considered separate species. Bowman (1960) considered _Euthemisto_ a subgenus of _Parathemisto_. Kane (1966) provided a good historical review of the taxonomic problems with this genus and followed Bowman's nomenclature, in which _Parathemisto gaudichaudii_ was considered to have two forms, _bispinosa_ and _compressa_. _P_. _gracilipes_ was considered a separate species. Sheader and Evans (1974) synonomized _P. gracilipes_ and _P. gaudichaudi_ into _P. gaudichaudi_ with the previously mentioned two forms. I followed Sheader and Evans' (1974) synonomy.

P. gaudichaudi clearly dominated the hyperiideans. In the surface waters, 98% of the hyperiidean individuals during cruise 01W and 99% in cruises 02W, 03W, and 05W were _P. gaudichaudi_. During cruise 04W, _P. gaudichaudi_ contributed only 13.8%. Even though _P. gaudichaudi_ consistently represented the bulk of the individuals present, some distinct changes in abundance and distribution occurred on the transect between cruises. For instance, although the percent contribution remained high from cruise to cruise (except 04W), the frequency of occurrence showed a marked decline in the surface waters (Table 16). The frequency of occurrence reached the lowest point during cruise 03W. A 33% decline in total frequency of occurrence took place between cruises 02W and 03W whereas total abundance dropped only 13%. These results indicate that _P. gaudichaudi_ became more highly concentrated in the spring and consequently more patchy in its distribution. During cruise 04W, the total abundance of _P. gaudichaudi_ continued to decline by 80% from cruise 03W while the frequency of occurrence increased by a small percentage (2.1%). At the same time, the total hyperiidean surface abundance increased by 41%.

The subsurface assemblages of hyperiideans were likewise dominated by _P. gaudichaudi_. In cruises 01W--03W,

TABLE 16

FREQUENCY OF OCCURRENCE, PERCENT CONTRIBUTION, AND MEAN NUMBERS/TOW OF P. GAUDICHAUDI IN THE SURFACE WATERS BY STATION FOR CRUISES 01W--04W

	Oct 75			Feb 76			May 76			Aug 76		
Station	Mean No./tow	% C	% F	Mean No./tow	% C	% F	Mean No./tow	% C	% F	Mean No./tow	% C	% F
C1	5.3	100	100	0.4	100	13	4.4	100	38	1.5	-	13
D1	19642.3	100	100	118.9	100	63	0.6	100	38	4.5	-	25
N3	7869.0	100	100	1504.0	100	88	942.5	100	50	264.6	15	75
E3	11746.0	100	100	5317.5	100	100	855.4	100	50	29.2	5	50
F2	49.1	100	100	286.8	100	88	1826.8	100	75	358.8	87	50
J1	1053.5	99	100	805.3	100	100	3316.9	99	50	805.9	94	100

Mean No./tow--mean number of individuals/tow for 8 standard tows
% C--percent contribution to total hyperiideans at station by gear
% F--frequency of occurrence as percent

90% or more of the hyperiideans at 15 of 18 stations belonged to this species (Table 17). The center of greatest abundance of P. *gaudichaudi* in the subsurface waters was station D1 during cruise 01W, station N3 during cruise 02W, and stations N3 and E3 during cruise 03W.

The results of cruise 05W provided some interesting comparisons. For instance, the center of abundance for P. *gaudichaudi* was again at station D1 and N3 (Table 18). Station B5 had the greatest abundance for the northern transect, although the subsurface abundance of P. *gaudichaudi* at A2 was high for a station on the slope. On the southern transect, L6 had the greatest surface abundance and a reasonably high subsurface mean number of individuals per m^3. Since the surface samples at station L1 were taken about two weeks prior to the subsurface samples, the data are not necessarily comparable.

P. *gaudichaudi* was the only species for which enough seasonal data was obtained to show diel trends throughout the year. The diel trends during cruise 01W at stations N3, E3, F2, and J1 showed a dawn/dusk double peak migration to the surface (Figure 5). The same general pattern was encountered during the cruise in February 1976 (Figure 6). In May 1976, however, a very curious change occurred at stations N3, E3, F2, and J1, which showed a single very predominate peak of abundance around 2000 hours (Figure 7). The diel pattern of cruise 04W showed signs of returning to the original dawn/dusk pattern (Figure 8) but

TABLE 17

MEAN NUMBER OF P. GAUDICHAUDI PER VOLUME FILTERED, AND PERCENT CONTRIBUTION IN SUBSURFACE WATERS BY STATION FOR CRUISES 01W--04W

Station	Oct 75 Mean No./m^3	Oct 75 % C	Feb 76 Mean No./m^3	Feb 76 % C	May 76 Mean No./m^3	May 76 % C	Aug 76 Mean No./m^3	Aug 76 % C
C1	-	-	-		-	100	-	-
D1	60.5	100	0.3	99	-	100	6.6	57
N3	5.1	100	15.3	100	2.8	100	16.2	93
E3	3.2	100	1.9	100	2.8	100	2.0	92
F2	0.1	100		90	1.6	100	1.6	93
J1		49		100	0.4	96	0.1	19

% C--percent contribution of total hyperiideans for station by gear

TABLE 18

MEAN NUMBER PER TOW AND PER VOLUME FILTERED, PERCENT CONTRIBUTION AND FREQUENCY OF OCCURRENCE FOR *P. GAUDICHAUDI* BY STATION DURING CRUISE 05W

Station	Surface Mean No./tow	Surface % C	Surface Freq	Subsurface Mean No./m^3	Subsurface % C
C1	1.9	100	38	*	100
D1	-		-	61.4	100
N3	-	-	-	5.6	100
E3	4112.6	100	100	15.2	100
F2	-	-	-	0.5	89
J1	1250.9	100	100	0.4	95
B5	9391.9	100	100	30.3	100
A2	606.6	100	100	3.5	99
L1	1.0	*	13	18.5	99
L2	796.3	92	100	@	@
L4	1297.6	100	100	0.5	87
L6	15,727.0	99	100	0.7	92

% C--percent contribution
Freq--Frequency of occurrence as percent
\- not a 24 hour station
* less than 0.1%
@ no individuals taken

FIGURE 5. Diel migratory pattern of _P_. _gaudichaudi_ for O1W based on eight consecutive neuston samples at each station

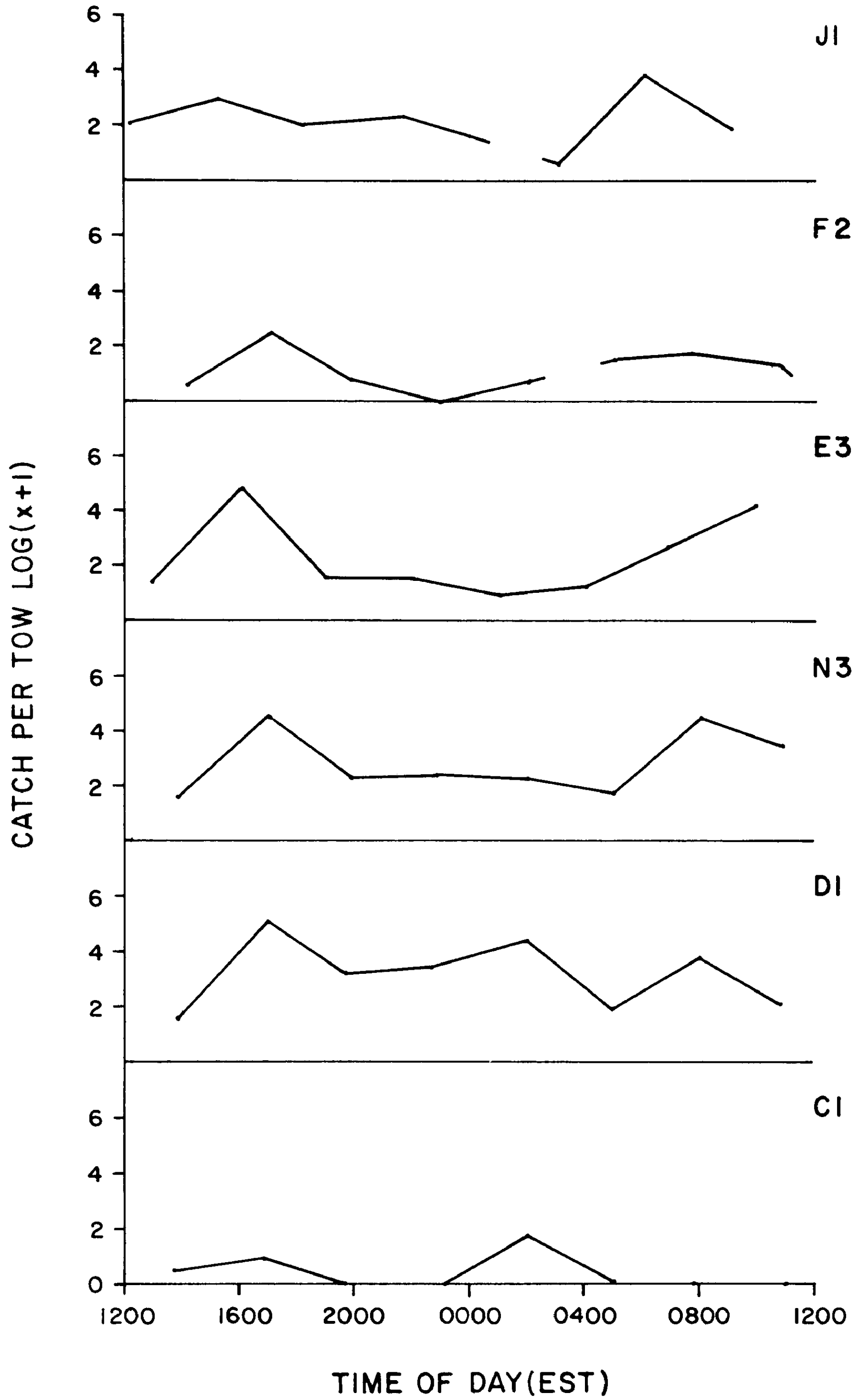

J1
F2
E3
N3
D1
C1
6
4
2
0
1200
1600
2000
0000
0400
0800
1200
CATCH PER TOW LOG(x+1)
TIME OF DAY(EST)

FIGURE 6. Diel migratory pattern for *P. gaudichaudi* for 02W based on eight consecutive neuston samples at each station

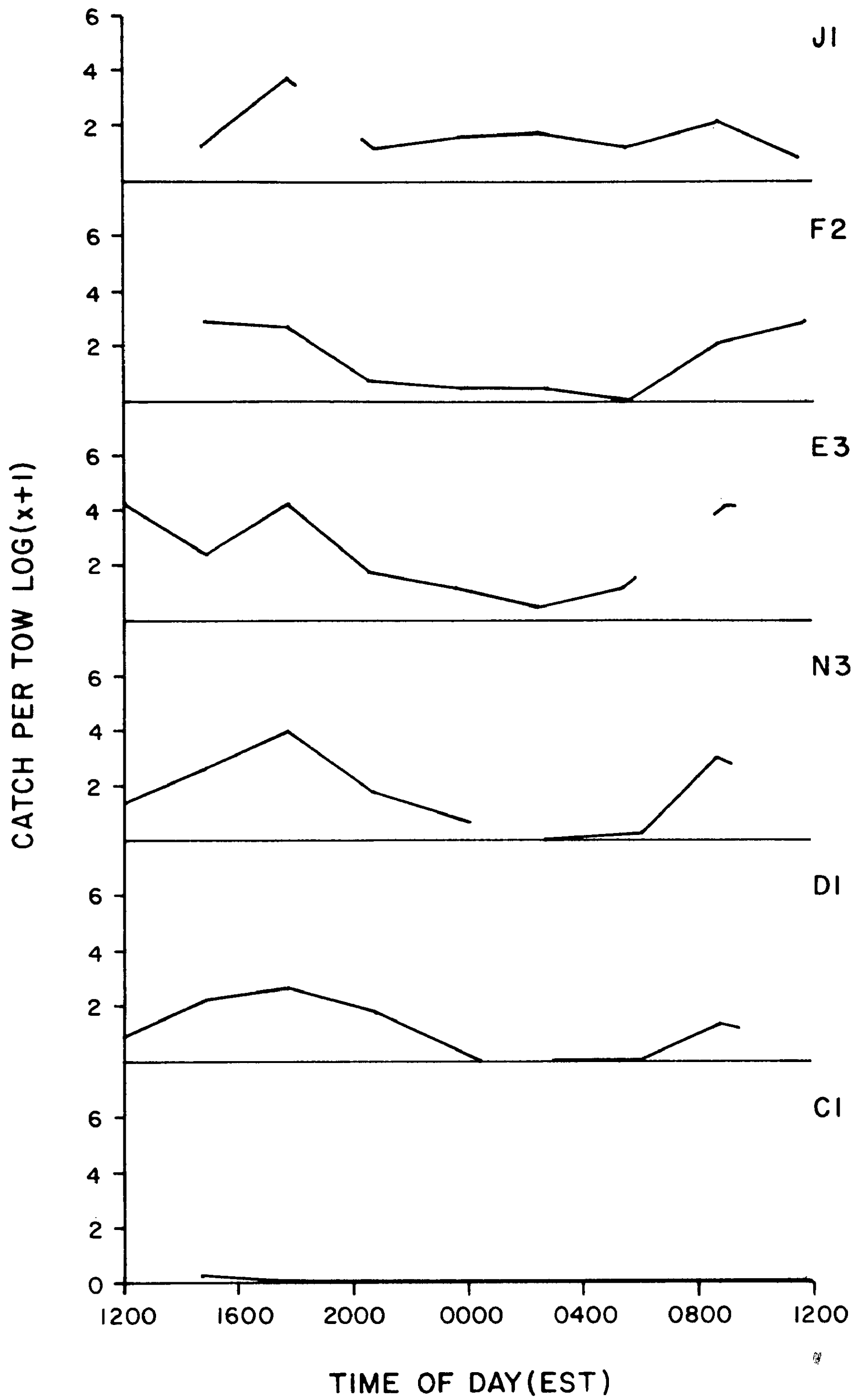
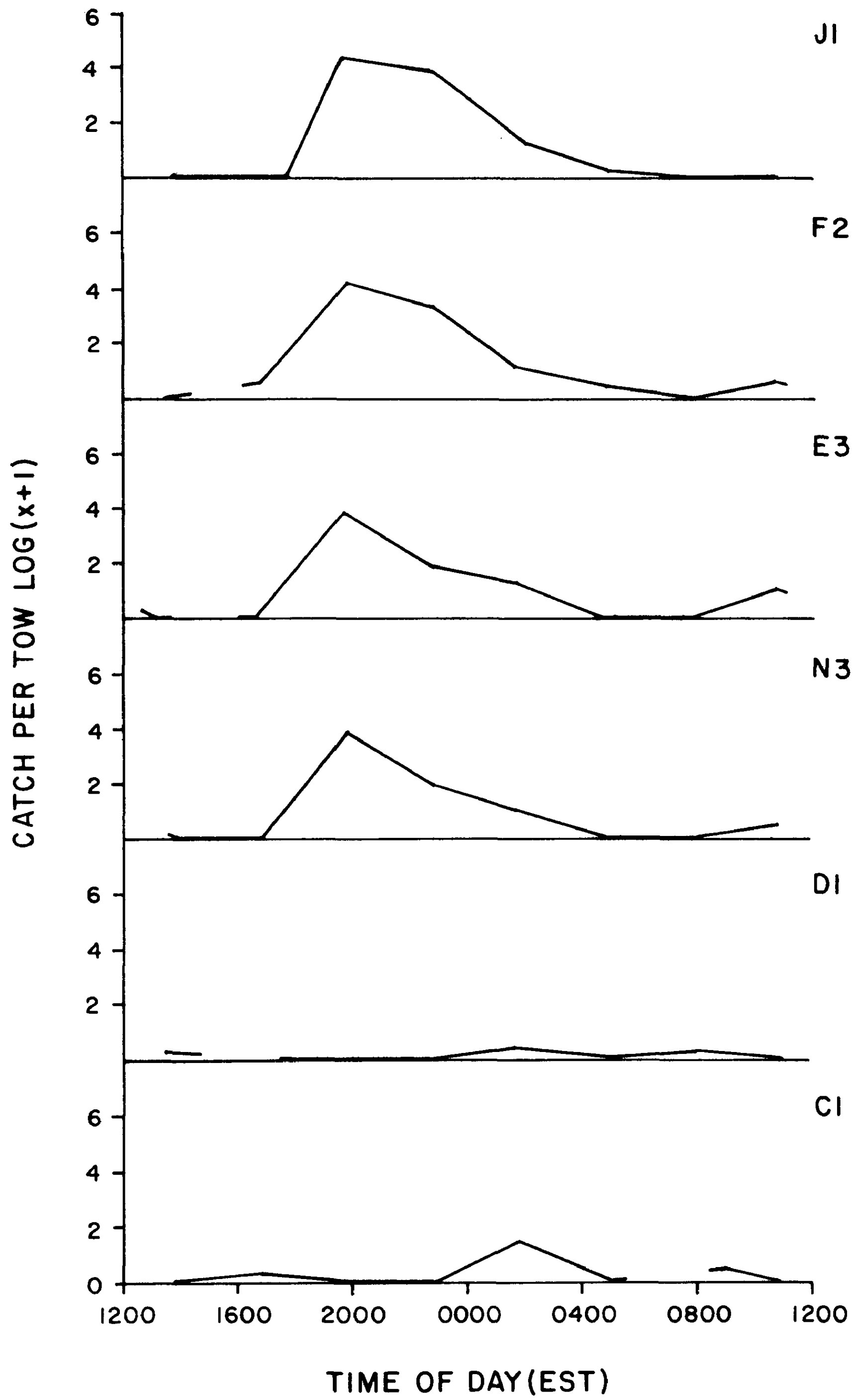
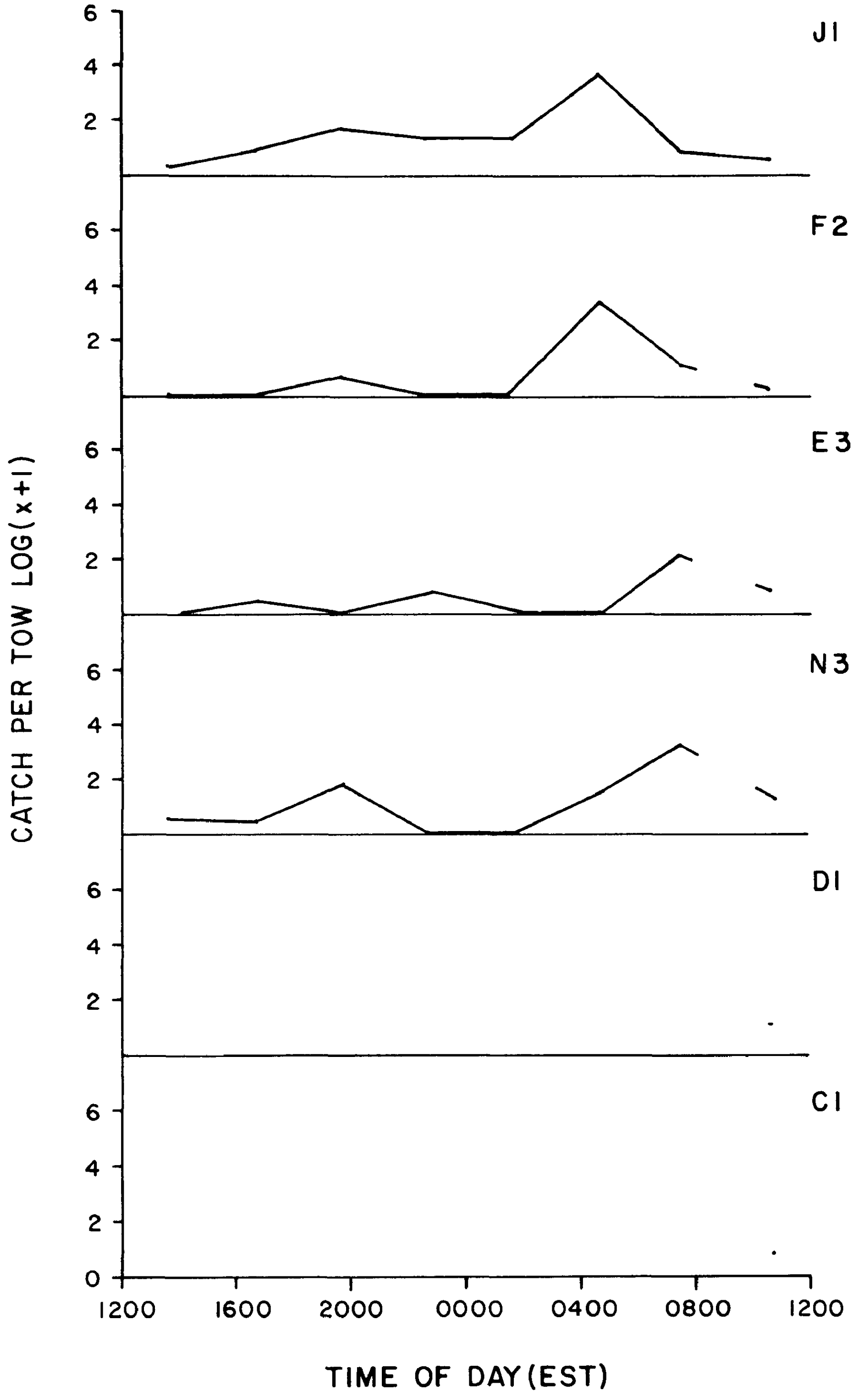

J1
F2
E3
N3
D1
C1
CATCH PER TOW LOG(x+1)
6
4
2
0
1200
1600
2000
0000
0400
0800
1200
TIME OF DAY(EST)

FIGURE 7. Diel migratory pattern for P. gaudichaudi for 03W based on eight consecutive neuston samples at each station



J1
F2
E3
N3
D1
C1
0
2
4
6
1200
1600
2000
0000
0400
0800
1200
CATCH PER TOW LOG (x+1)
TIME OF DAY (EST)

FIGURE 8. Diel migratory pattern for *P. gaudichaudi* for 04W based on eight consecutive neuston samples at each station.


J1
F2
E3
N3
D1
C1
CATCH PER TOW LOG(x+1)
0
2
4
6
1200
1600
2000
0000
0400
0800
1200
TIME OF DAY (EST)

not as distinctly as in cruise 01W.

Phronimidae Dana, 1853

Phronima atlantica Guerin, 1836

The previous record of this species is listed in Table 1. This species was present in three surface samples in the present study at station F2--04W. Additionally, P. atlantica occurred in one surface sample at station J1 during cruise 04W and one surface sample at both station L4 and station E3 of cruise 05W. This species was collected in one of the bongo samples at station J1 cruise 01W, one bongo sample at both station E3 and station F2 of cruise 04W, and one bongo sample at stations L2, E3, and F2 of cruise 05W. The total numbers from both years was relatively small. Bigelow found this species in 0-300m of water.

Phronimella elongata (Claus, 1862)

The previous record of this species is listed in Table 1. This species occurred in 50% of the bongo samples taken during 04W and mainly at the offshore stations. The total number taken during that cruise was 68 which is quite high in comparison to all other species except P. gaudichaudi and L. bengalensis. P. elongata occurred in one neuston tow at station J1 of cruise 04W. The remaining occurrences of this species were in the subsurface samples of station J1 of cruise 01W and stations L2, E3, and F2 of cruise 05W.

Phrosinidae Dana, 1853

Phrosina _semilunata_ Risso, 1822

The previous record of this species is listed in Table 1. The occurrence of this species in the present study was consistent with the findings of previous studies of the area. _P_. _semilunata_ occurred in half of the neuston samples at J1--04W and contributed a total of 88 individuals. In addition, it was present in 33% of the bongo tows of 04W supplying 81 individuals from station E3 seaward. Also, _P_. _semilunata_ occurred in one surface sample at station J1 cruise 01W and one subsurface sample at station J1 cruise 01W and stations L4, L6, and A2 cruise 05W. In Bigelow (1917), and Grice and Hart (1962), the occurrence was likewise at stations very close to the shelf edge.

Anchylomera _blossevillii_ Milne-Edwards, 1830

The previous record of this species is listed in Table 1. This species occurred in 33% of the bongo tows during 04W. In the surface waters, _A_. _blossevillii_ occurred at both F2--04W and J1--04W in two out of eight neuston samples. A total of 33 individuals was collected in the bongo tows and 22 individuals in the neuston tows. This species was also present in the surface samples at station J1 cruise 01W and stations L4 and L6 of cruise 05W. Additional specimens were obtained in the subsurface samples at station J1 cruise 01W and station A2 cruise 05W. Grice and Hart (1962) found

A. blossevillii in December in a warm water intrusion on the shelf.

Lycaeopsidae Chevereux, 1913

Lycaeopsis neglecta Pirlot, 1929

No previous record of this species in the Middle Atlantic Bight was found. This species was present in 3 of 12 bongo samples during cruise 04W and totaled 11 individuals. In addition, this species occurred in the neuston of station J1 cruise 04W and stations L1 and D1 of cruise 05W.

Lycaeopsis zamboangae Claus, 1879

No previous record of this species was found. *L. zamboangae* was present in a total of seven neuston tows for 04W. Three of the tows were from station E3, two tows were from station F2, and one tow each was from station N3 and station J1. These samples yielded 357 individuals in the surface waters. Additionally, *L. zamboangae* was present in three bongo tows for 04W which supplied only three individuals from stations E3, F2, and J1. *L. zamboangae* occurred during cruise 05W in two neuston tows from station L2 and one bongo tow from L2. This species represented one of the top ranked second order species behind *P. gaudichaudi* and *L. bengalensis*.

Phronoidae Claus, 1879

Eupronoe armata Claus, 1879

No previous record of this species was found for the Middle Atlantic Bight. *E. armata* occurred in three of twelve bongo tows during 04W which yielded a total of 22 individuals at stations E3, F2, and J1. *E. armata* occurred in one surface sample at stations F2 and J1 during cruise 04W. *E. armata* was also present in one bongo tow and one neuston tow at station L4 during cruise 05W.

Eupronoe minuta Claus, 1879

No previous record of this species was found for the Middle Atlantic Bight. This species was present in four neuston samples during 04W with two of those occurring at F2 and one surface sample at E3 and J1 for a total of 41 individuals. In the subsurface samples, *E. minuta* was present in 4 of 12 samples from station E3 seaward which supplied 13 individuals. During cruise 05W, this species occurred in one surface sample at station L4 and station L6. *E. minuta* was also present in four bongo tows at station A2, two bongo tows at station F2, and one bongo tow at station J1 for cruise 05W.

Lycaeidae Claus, 1879

Brachyscelus crusculum Bate, 1861

No previous record from the Middle Atlantic Bight was found. B. crusculum occurred in 25% of the bongo tows of 04W and 25% of the neuston samples of F2--04W and J1--04W. A total of 12 individuals was collected in the bongo samples and 7 and 3 individuals in the surface samples of station F2 and J1 respectively. Only a small number of individuals was collected.

Brachyscelus macrocephalus Stephensen, 1925

No previous record was found for the Middle Atlantic Bight. This species occurred in 2 of 8 neuston samples at J1--04W and only two individuals were collected. One specimen was collected in the bongo samples of station L2 during cruise 05W.

Platyscelidae Bate, 1862

Platyscelus serratulus Stebbing, 1888

No previous record was found for the Middle Atlantic Bight. P. serratulus occurred in 4 of 12 bongo samples from station E3 seaward during 04W. A total of 33 individuals was collected in subsurface samples. At stations F2--04W and J1--04W, P. serratulus occurred in 2 of 8 surface samples providing a cumulative total of 38 individuals.

Hemityphis rapax (Milne-Edwards, 1830)

No previous record of this species was found for the Middle Atlantic Bight. H. rapax was collected in 3 of 12 bongo tows during cruise 04W and occurred from station E3 seaward. A total of 19 individuals was collected from the bongo tows. *H. rapax* occurred in one surface sample at stations E3, F2, and J1 of cruise 04W. This species was also present in one surface sample at station L4 cruise 05W.

Paratyphis parvus Claus, 1887

No previous record of this species was found for the Middle Atlantic Bight. *P. parvus* occurred in 5 of 12 bongo samples during cruise 04W. As in the above species of this family, *P. parvus* occurred from station E3 seaward. A total of 33 individuals was collected in the subsurface samples. This species was also present in one surface sample at stations E3, F2, and J1 during cruise 04W.

Tetrathyrus forcipatus Claus, 1879

No previous record of this species was found for the Middle Atlantic Bight. *T. forcipatus* was taken in 12 neuston samples during 04W. At stations D1 and J1, this species had a 50% frequency of occurrence in the surface waters. At stations E3--04W and F2--04W, this species had a 38% frequency of occurrence. A total of 158 individuals was collected in the neuston samples. Five of 12 bongo samples from cruise 04W contained this species. The samples were from stations D1, E3, F2, and J1 and contributed 84 individuals. During cruise 05W, this species occurred in one bongo sample at station L2 and station L4. In addition, one neuston sample from station L4 and station L6 and two neuston samples at station L2 contained *T. forcipatus*. This species was the fourth most abundant species.

Parascelidae Bovallius, 1887

Thyropus sphaeroma (Claus, 1879)

No previous record for this species was found for the Middle Atlantic Bight. *T. sphaeroma* occurred in the surface waters at stations D1, E3, F2, and J1 for cruise 04W but only at station J1--04W did it occur in two or more surface tows. The total number of individuals taken in the surface at station J1 was 15. In addition this species was present in 3 of 12 bongo samples from cruise 04W. Those samples were from stations E3 and J1 and yielded 12 individuals.

DISCUSSION

Most amphipods in the suborder Hyperiidea have been categorized as oceanic (Bowman and Gruner 1973), but some are obviously neritic. The seasonal data collected from the C1--J1 transect affords the opportunity to obtain some information on the general ecology of the hyperiideans taken over the continental shelf. Two different systems based on separate criteria can be used to categorize the species collected. Both systems are presented in the same table and are arranged according to the sampling gear employed. The first system is based on species occurrence patterns on the shelf and will provide some general indication of the distribution of the hyperiideans. In this system, two categories were defined, namely, the transshelf group (occurring at every station of the transect), and the offshore group (occurring from station E3 seaward). The second system is based on species abundance patterns (total number sampled) and will provide a relative idea of how frequently a given species could be encountered in relation to the other hyperiideans. Three categories, based on total abundance, were identified: 1) rare (means 1 to 9 individuals), 2) frequent (means 10^1 to 10^2 individuals), and 3) abundant (means 10^3 or greater individuals).

Subsurface Assemblage

The fauna from the bongo samples are divided into a transshelf group with two species and an offshore group with 47 species (Table 19). *Parathemisto gaudichaudi* and *Lestrigonus bengalensis* were the only two species considered transshelf. These were also the only two species that were considered abundant and *P. gaudichaudi* was the only species that was abundant during all five cruises. Of the remaining 48 species, 29 were rare and 19 were frequent in abundance. Most of the 47 offshore species were taken during cruise 04W. As was pointed out earlier, this offshore species component appeared at station E3 and was consistent out to station J1. This increase in the number of species coincided with an intrusion of "slope water" (Ruzecki, Welch, and Baker 1977). Vecchione (1979) postulated that the mollusk *Limacina trochiformis* may have been transported across the shelf via Gulf Stream eddies in November 1976. In 1914, Bigelow (1917) also encountered a warm water intrusion, but he did not encounter it in other years. Sears and Clark (1940) stated that seldom are oceanic species found

> ". . . more that 10-15 miles inside the 200 meter contour"

which is seaward of the location of station E3 from the present study. Although the intrusion has been observed several times, the phenomenon is very unpredictable.

TABLE 19

SUBSURFACE SPECIES DISTRIBUTIONAL ABUNDANCE PATTERNS

	Grouping		Abundance Pattern (order of magnitude)						
Species	Dist.	Abund.	01W	02W	03W	04W	05W		
Hyperia galba	O.S.	rare		$<10^1$					
Hyperia medusarum	O.S.	rare				$<10^1$			
Hyperietta stephenseni	O.S.	rare	$<10^1$						
Hyperietta vosseleri	O.S.	frequent	10^1			10^1	$<10^1$C	$<10^1$L	
Lestrigonus bengalensis	T.S.	abundant	10^1			10^3	10^2C	10^1L	10^1A
Lestrigonus crucipes	O.S.	rare				$<10^1$			
Lestrigonus latissimus	O.S.	rare				$<10^1$			
Lestrigonus schizogeneios	O.S.	frequent	10^1			$<10^1$			
Parathemisto gaudichaudi	T.S.	abundant	10^4	10^3	10^3	10^4	10^5C	10^3L	10^4A
Phronimopsis spinifera	O.S.	rare						$<10^1$L	$<10^1$A
Brachyscelus crusculum	O.S.	frequent				10^1			
Brachyscelus rapacoides	O.S.	rare				$<10^1$			
Lycaea bovallioides	O.S.	rare	$<10^1$						
Lycaea pulex	O.S.	rare				$<10^1$			
Tryphana malmi	O.S.	rare				$<10^1$	$<10^1$C		
Lycaeopsis neglecta	O.S.	frequent				10^1			
Lycaeopsis themistoides	O.S.	rare				$<10^1$			
Lycaeopsis zamboangae	O.S.	rare				$<10^1$		$<10^1$L	
Calamorhynchus pellucidus	O.S.	rare				$<10^1$			

Table 19 continued

Species	Grouping		Abundance Pattern (order of magnitude)						
	Dist.	Abund.	01W	02W	03W	04W	05W		
Cranocephalus sp.	O.S.	rare				$<10^1$			
Leptocotis tenuirostris	O.S.	rare				$<10^1$			$<10^1$A
Oxycephalus clausi	O.S.	rare				$<10^1$			
Oxycephalus piscator	O.S.	rare				$<10^1$			
Rhabdosoma armata	O.S.	rare				$<10^1$			
Rhabdosoma whitei	O.S.	rare				$<10^1$	$<10^1$C		
Streetsia challengeri	O.S.	rare							$<10^1$A
Streetsia mindanaonis	O.S.	rare				$<10^1$			
Streetsia porcella	O.S.	rare				$<10^1$			
Streetsia steenstrupi	O.S.	rare	$<10^1$			$<10^1$		$<10^1$L	
Tullbergella cuspidata	O.S.	rare				$<10^1$			
Paraphronima gracilis	O.S.	frequent		10^1		10^1	$<10^1$C	$<10^1$L	$<10^1$A
Thyropus sphaeroma	O.S.	frequent				10^1			
Phronima atlantica	O.S.	frequent	10^1			10^1	10^1C	10^1L	10^1A
Phronima colletti	O.S.	rare				$<10^1$		$<10^1$L	
Phronima pacifica	O.S.	rare				$<10^1$		$<10^1$L	
Phronima sedentaria	O.S.	frequent	10^1	10^1			10^1C		
Phronimella elongata	O.S.	frequent	$<10^1$			10^1	$<10^1$C	$<10^1$L	$<10^1$A
Anchylomera blossevillii	O.S.	frequent	10^1			10^1			$<10^1$A
Phrosina semilunata	O.S.	frequent	10^1			10^1		10^1L	$<10^1$A
Primno brevidens	O.S.	frequent	10^1			10^1	$<10^1$C		$<10^1$A
Primno johnsoni	O.S.	rare				$<10^1$	$<10^1$C		$<10^1$A
Primno latreillei	O.S.	rare				$<10^1$			

Table 19 continued

Species	Grouping		Abundance Pattern (order of magnitude)						
	Dist.	Abund.	01W	02W	03W	04W	05W		
Amphithyrus sculpturatus	O.S.	rare							$<10^1$A
Hemityphis rapax	O.S.	frequent				10^1	10^1C		
Paratyphis parvas	O.S.	frequent				10^1	10^1C		
Platyscelus serratulus	O.S.	frequent				10^1			
Tetrathyrus forcipatus	O.S.	frequent				10^1		10^1L	
Eupronoe armata	O.S.	frequent				10^1		$<10^1$L	
Eupronoe minuta	O.S.	frequent				10^1	10^1C	$<10^1$L	10^2A
Sympronoe parva	O.S.	rare				$<10^1$			
Vibilia armata	O.S.	rare				$<10^1$			
Scina stenopus	O.S.	rare					$<10^1$C	$<10^1$L	
Scina stebbingi	O.S.	frequent			10^1				

O.S.--offshore species
T.S.--transshelf species
C--C1-J1 transect
L--L1-L6 transect
A--A2-B5 transect
Dist.--Distribution
Abund.--Abundance

Consequently, the influx of the offshore component of hyperiideans cannot be predicted on a seasonal basis.

Surface Assemblage

Of the 43 species taken in the surface samples, only *P. gaudichaudi* and *L. bengalensis* were determined to be abundant (Table 20). Once again these two species were observed to be transshelf in distribution. Six species did not fit the groupings since they occurred at a different arrangement of stations than used in the groupings. Three of these species, *Themistella fusca*, *Thamneus platyrrhynchus*, and *Iulopis loveni*, were from the southern component. Four species were considered inshore species, two of which were rare. *Hyperoche mediterranea* was one of the inshore frequent species which is consistent with previous records of this genus (Flores and Brusca 1975, and Bigelow 1926). There were 12 offshore rare species and 17 offshore frequently occurring species, for a total of 29 offshore surface species. Once again at station E3, a marked increase in number of species occurred when compared to station N3.

Surface and Subsurface Distributional Comparison

Twenty-four species co-occurred in both surface and subsurface samples and were present from station E3 seaward (the offshore component). Of the 63 total species

TABLE 20

SURFACE SPECIES DISTRIBUTIONAL ABUNDANCE PATTERNS

Species	Grouping		Abundance Pattern (order of magnitude)				
	Dist.	Abund.	01W	02W	03W	04W	05W
Hyperietta stephenseni	I.S.	frequent				10^2	
Hyperietta vosseleri	I.S.	rare	$<10^1$				
Hyperoche mediterranea	I.S.	frequent				10^1	
Iulopis loveni		frequent					10^1L
Lestrigonus bengalensis	T.S.	abundant	10^1			10^4	10^4L $<10^1$A
Lestrigonus crucipes	O.S.	rare	$<10^1$				
Lestrigonus latissimus	O.S.	frequent	10^1			10^1	
Lestrigonus schizogeneios	O.S.	frequent	10^1			10^1	10^1L
Parathemisto gaudichaudi	T.S.	abundant	10^5	10^4	10^4	10^4	10^5L 10^4A
Phronimopsis spinifera	O.S.	frequent					10^1L 10^1A
Themistella fusca		frequent					10^2L
Brachyscelus crusculum	O.S.	frequent	10^1			10^1	
Brachyscelus macrocephalus	O.S.	frequent				$<10^1$	10^1L
Brachyscelus rapacoides	O.S.	rare				$<10^1$	
Lycaea pulex	O.S.	rare					$<10^1$L
Thamneus platyrrhynchus		rare					$<10^1$L
Tryphana malmi	O.S.	rare		$<10^1$			
Lycaeopsis neglecta	O.S.	frequent				10^1	10^1L
Lycaeopsis themistoides	O.S.	frequent				10^1	
Lycaeopsis zamboangae	O.S.	frequent				10^2	10^1L

Table 20 continued

Species	Grouping		Abundance Pattern (order of magnitude)				
	Dist.	Abund.	01W	02W	03W	04W	05W
Glossocephalus milne-edwardsi	I.S.	rare				$<10^1$	
Oxycephalus clausi		rare					$<10^1$L
Oxycephalus piscator	O.S.	rare				$<10^1$	
Thyropus sphaeroma	O.S.	frequent				10^1	
Thyropus edwardsi	O.S.	frequent				10^1	
Phronima atlantica		frequent				10^1	$<10^1$L
Phronima colletti		rare					$<10^1$L
Phronima sedentaria		rare					$<10^1$A
Phronimella elongata	O.S.	rare				$<10^1$	
Anchylomera blossevillii	O.S.	frequent	10^1			10^1	10^1L
Phrosina semilunata	O.S.	frequent	10^1			10^1	
Amphythyrus sculpturatus	O.S.	rare				$<10^1$	
Hemityphis rapax	O.S.	frequent				10^1	10^1L
Paratyphis parvas	O.S.	rare				$<10^1$	
Platyscelus serratulus	O.S.	frequent				10^1	
Tetrathyrus forcipatus	O.S.	frequent	10^1			10^2	10^1L
Eupronoe armata	O.S.	frequent				10^1	10^1L
Eupronoe minuta	O.S.	frequent				10^1	10^1L
Paralycea sp.	O.S.	rare				$<10^1$	
Sympronoe parva	O.S.	rare				$<10^1$	
Vibilia armata	O.S.	rare				$<10^1$	

Table 20 continued

Species	Grouping		Abundance Pattern (order of magnitude)				
	Dist.	Abund.	01W	02W	03W	04W	05W
Scina damasii	O.S.	frequent			10^1		
Scina curvidactyla	O.S.	rare			$<10^1$		
Scina stebbingi	O.S.	frequent			10^2		

O.S.--offshore species
T.S.--transshelf species
A--A2-B5 transect
L--L1-L6 transect
Dist.--Distribution
Abund.--Abundance

collected, 55 are observed to be from the offshore component. Ten species were taken only in the neuston and 21 species were taken solely from subsurface samples. P. gaudichaudi and L. bengalensis clearly dominated the surface and subsurface samples across the entire C1--J1 transect.

Grant (1979) employed normal and inverse clustering, plus nodal analysis techniques to identify species groups with similar distributional patterns in the total zooplankton from the same collections. In his summary of the first and second year of cruises, he noted that the "principal division of collections was not between seasons, but between inshore and offshore location". The bongo samples from the summer of 1976 were part of an offshore cluster consisting of summer samples. Grant considered several species groups as being the key determining factor in his clustering results. One group was dominated by hyperiideans and Anchylomera blossevillii, Phronima atlantica, Phronimella elongata, Phrosina semilunata, and Tetrathyrus forcipatus were the species comprising that group. The detailed analysis of hyperiideans in the present study are consistent with his findings.

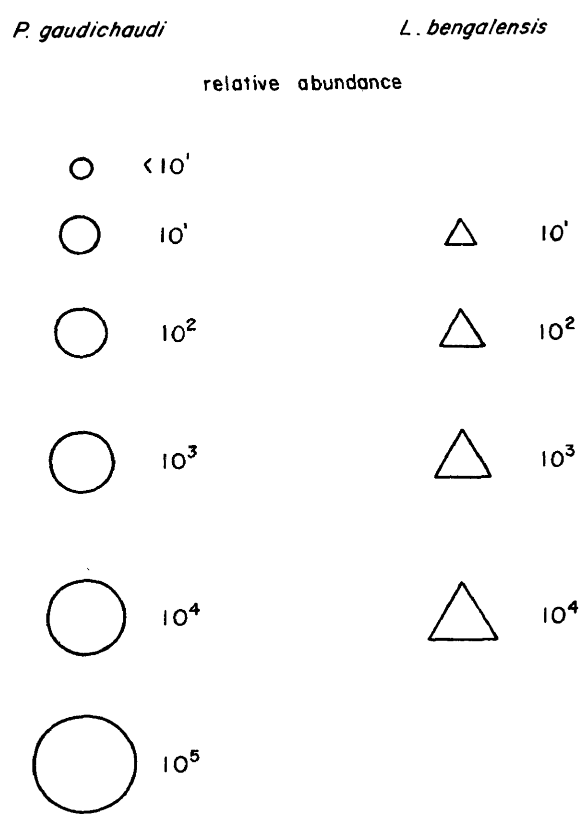
P. gaudichaudi and L. bengalensis Relationships

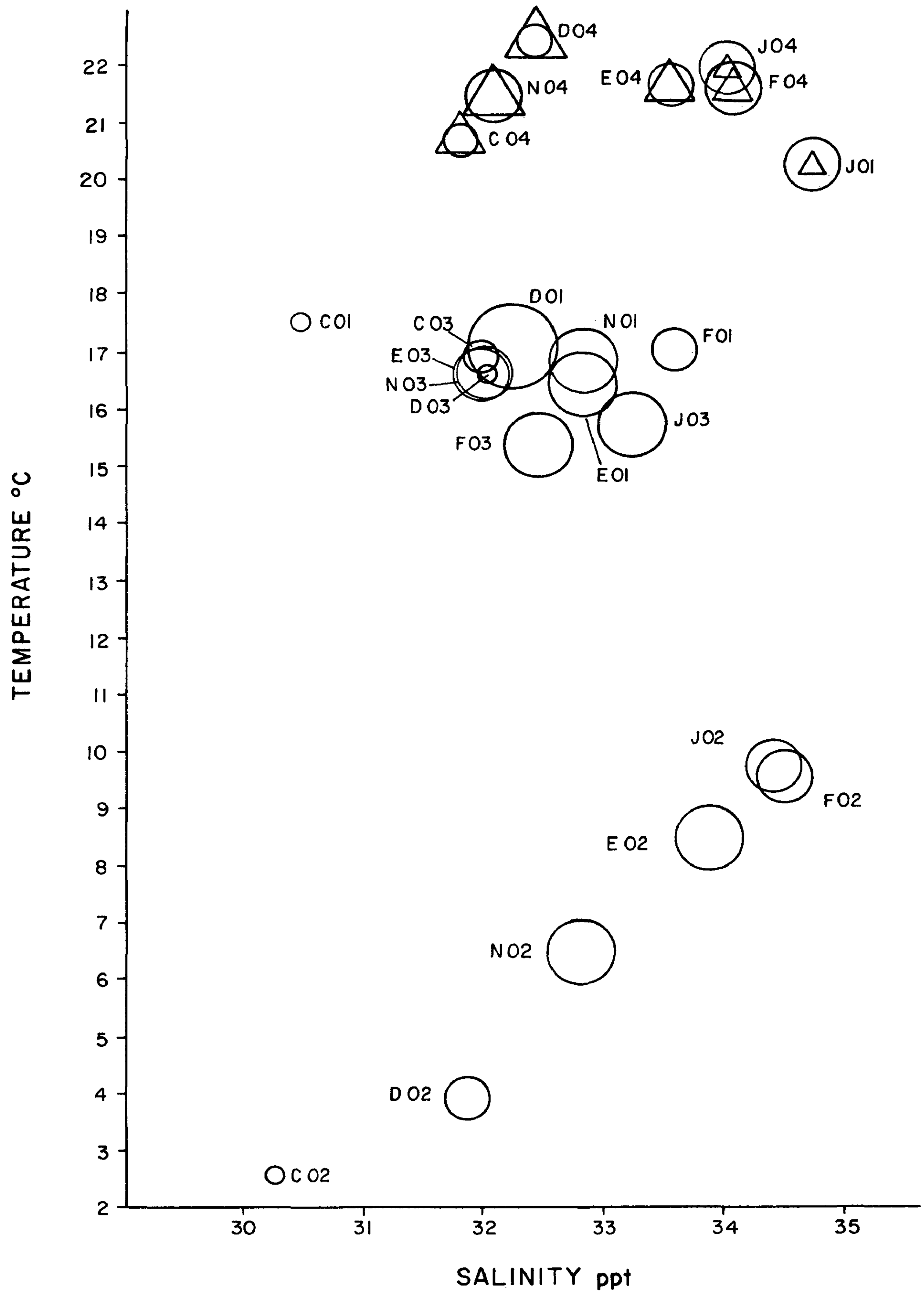
These two species provide some interesting comparisons.

Bowman (1960) discussed the cold water existence of _P. gaudichaudi_ and Bowman (1973) stated the coastal warm water distribution of _L. bengalensis_, facts which were also evident in the present study. In addition, the peak abundance of _P. gaudichaudi_ occurred between the months of September and January inclusive. The data in Tables 15 and 17 support this conclusion and indicate that the maximum abundance occurs in either September or October. Comparatively speaking, _P. gaudichaudi_ is eurythermic (Figure 9) and not surprisingly, was relatively abundant during the entire year. _L. bengalensis_, on the other hand, is stenothermic and is present mainly during the summer months; i.e. June through September and rarely in the other months. _P. gaudichaudi_ never developed much of a population at station C1 while _L. bengalensis_ had a relatively large population at station C1. This fact emphasizes the coastal nature of _L. bengalensis_. The data in the present study tend to indicate that both species are neritic in this portion of the northwest Atlantic Ocean which, in the case of _P. gaudichaudi_, supports the findings of Bigelow (1915).

During cruise 04W of the present study, these two species maintained their centers of greatest abundance at opposite ends of the transect (Figure 10). In addition these two species exhibited a parallel diel migratory pattern during cruise 05W at station L2 (Figure 11) and at J1--04W (Figures 4 and 8). Consequently, even though

FIGURE 9. Average sea surface salinity, average sea surface temperature, relative total abundance for P. gaudichaudi and L. bengalensis, cruises 01W--04W, letter designates station and number designates cruise





TEMPERATURE °C
SALINITY ppt
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
30
31
32
33
34
35
D04
J04
E04
F04
N04
C04
J01
D01
C01
C03
N01
F01
E03
N03
D03
J03
F03
E01
J02
F02
E02
N02
D02
C02

FIGURE 10. Total surface individuals (x) for *P. gaudichaudi* and *L. bengalensis* on C1-J1 transect cruise 04W

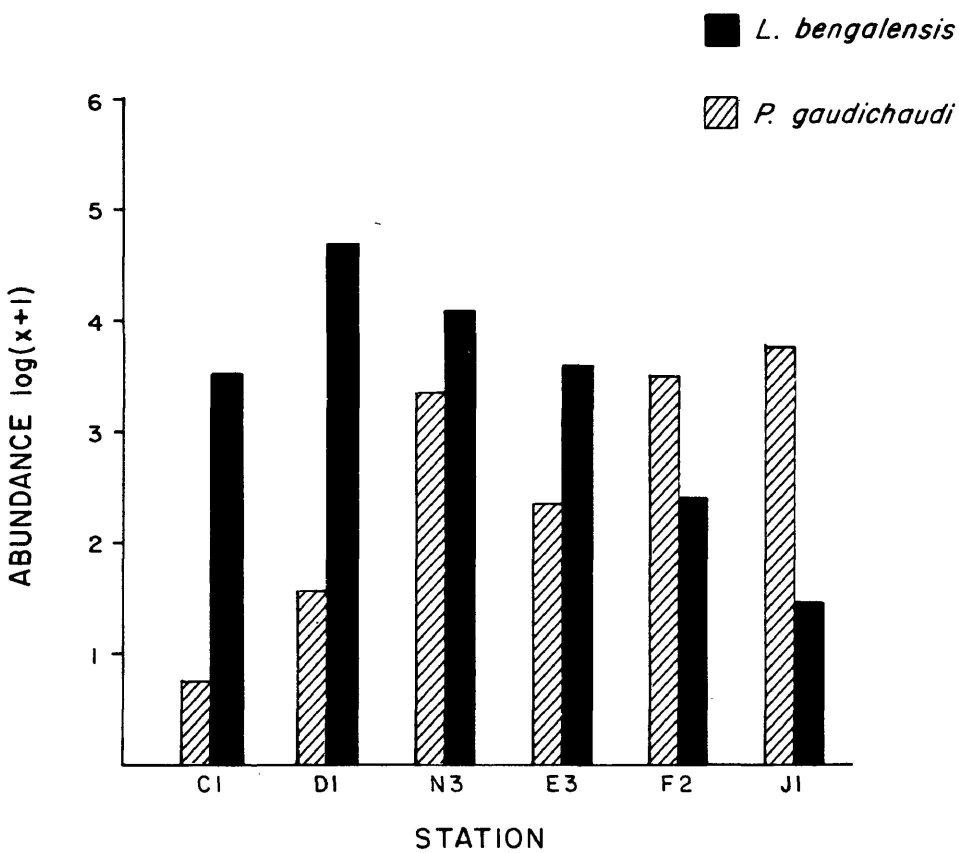
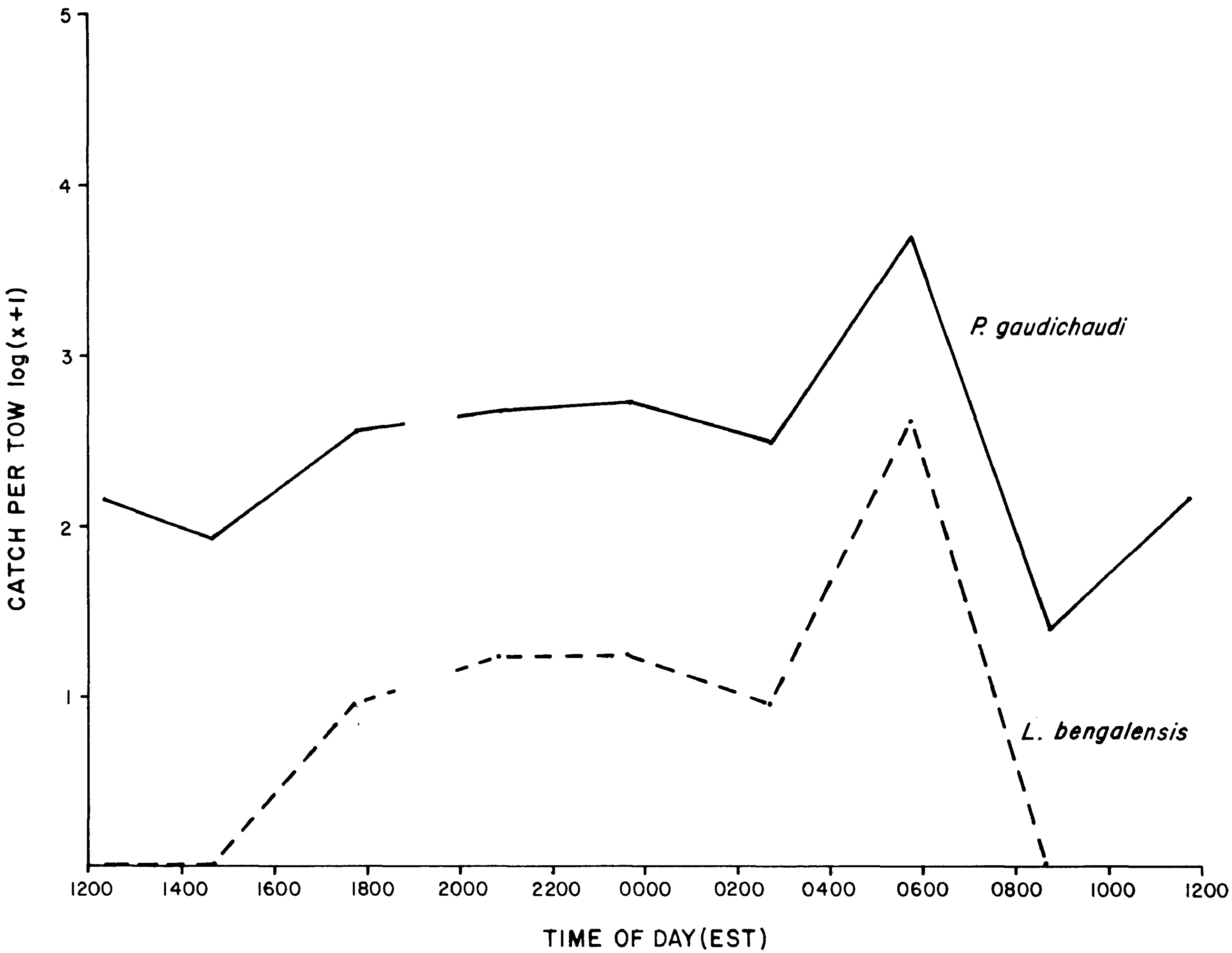

L. bengalensis
P. gaudichaudi
ABUNDANCE log(x+1)
6
5
4
3
2
1
C1
D1
N3
E3
F2
J1
STATION

FIGURE 11. Diel migratory pattern of P. gaudichaudi and L. bengalensis at station L2, cruise 05W


CATCH PER TOW log(x+1)
5
4
3
2
1
P. gaudichaudi
L. bengalensis
1200
1400
1600
1800
2000
2200
0000
0200
0400
0600
0800
1000
1200
TIME OF DAY (EST)

one species is a warm water form and the other a cold water form, it appears that both species react in a similar manner under certain vertical migratory stimuli. Light, in this instance, does not seem to be the controlling factor since the migratory patterns were not parallel at every station where they co-occurred.

Comparison With Other Atlantic Ocean Studies

Morris (1975) analyzed a collection of hyperiideans taken in a neuston net from a transect across the Gulf Stream between Bermuda and Halifax. He observed *Eupronoe minuta* and *Hyperia atlantica* (*L. bengalensis*, T. E. Bowman, personal communication) to dominate in his neuston samples from the northwest Atlantic Ocean. In contrast, the neuston samples from this study were dominated by *Parathemisto gaudichaudi* in all cruises except August 1976 when *Lestrigonus bengalensis* was the most abundant species. Thurston (1976) analyzed neuston samples from the Sond Cruise, which covered an area off Fuerteventura in the Canary Islands, located at approximately 29°N 15°W. He found *Anchylomera blossevillii* as the dominant species in the neuston with *Lestrigonus schizogeneios* and *L. bengalensis* ranked second and third respectively. From these data, it is apparent that different species of hyperiideans dominate the surface waters in different parts of the Atlantic Ocean and suggests the need for an atlas.

In several studies, the subsurface hyperiideans were sampled in the Atlantic Ocean and many of the species taken were the same species as those found in the present study. Thurston (1976) found 78 species in his samples collected off Fuerteventura in the Canary Islands of which 39 species were the same as those found in the offshore subsurface assemblage of the present study. Thurston's samples were taken from water depths in excess of 1000m while those in the present study were taken from less than 600m. The dominant subsurface species that Thurston found was <u>Primno macropa</u> (actually <u>P. johnsoni</u>, according to T. E. Bowman, personal communication). Hoffer (1972) reported that <u>Parathemisto abyssorum</u> was the dominant hyperiidean in the Gulf of St. Lawrence while Tencati and Gieger (1967) found <u>Parathemisto libellula</u> to be the most common hyperiidean in the slope water of northeast Greenland. Whitely (1948) reported that <u>Themisto compressa</u> was very common outside the 100m contour on Georges Bank in July and August, but suggested that temperatures above 15°C and below 5°C were unfavorable for the species. <u>Parathemisto gaudichaudi</u> was the dominant subsurface species during the present study and was very abundant at temperatures down to 3°C.

Consequently, from the findings of the present study, plus the findings of Hoffer (1972), Tencati and Geiger

(1967), Whitely (1948), and Bigelow (1926), one fact is evident: Parathemisto spp. is the most dominant hyperiidean genus in the shelf waters of the northwest Atlantic Ocean from the mouth of the Chesapeake Bay north.

In conclusion, it is apparent from the rare occurrences of the offshore species component combined with Grant's (1979) findings, that a project aimed at identifying the long term cyclical fluctuations of species composition and abundance of the hyperiideans, as well as the associated zooplankton is in order.

Summary

1. *Parathemisto gaudichaudi* was the dominant hyperiidean in both the surface and subsurface assemblages except in September 1976.
2. The summer cruise (September 1976) revealed an influx of an offshore component of hyperiideans that was associated with a slope water intrusion.
3. *Lestrigonus bengalensis* occurred in warm shelf waters, whereas, *Parathemisto gaudichaudi* occurred in cold shelf waters.
4. More warm water species were collected when the southern transect was sampled.
5. The hyperiidean assemblage was virtually monospecific in the winter season.
6. Fifty three species taken in the present study were not previously reported from the study area.

LITERATURE CITED

Barnard, K. H. 1930. Crustacea, Part IX: Amphipoda. In: The British Antarctic (Terra Nova) Expedition, 1910. Natural History Report, Zoology, 8:307-454.

Bigelow, H. B. 1915. Exploration of the coast water between Nova Scotia and Chesapeake Bay, July and August, 1913, by the U.S. Fisheries Schooner Grampus. Oceanography and Plankton. Bull. Mus. Comp. Zool. 59:149-359.

Bigelow, H. B. 1917. Explorations of the coast water between Cape Cod and Halifax in 1914, and 1915, by the U.S. Fisheries Schooner Grampus. Oceanography and Plankton. Bull. Mus. Comp. Zool. 61:161-357.

Bigelow, H. B. 1922. Explorations of the coastal water off the Northeastern United States in 1916 by the U.S. Fisheries Schooner Grampus. Bull. Mus. Comp. Zool. 65:85-188.

Bigelow, H. B. 1926. Plankton of the offshore waters of the Gulf of Mexico. Bull. U. S. Bur. Fish. 40:1-509.

Bigelow, H. B. and M. Sears, 1939. Studies of the waters of the Continental Shelf, Cape Cod to Chesapeake Bay. III. A volumetric study of the zooplankton. Mem. Mus. Comp. Zool. 54:189-378.

Bovallius, C. 1889. Contributions to a monograph of the Amphipoda Hyperiidea, Part I; 2. The families Cyllopodidae, Paraphronimidae, Thaumatopsidae, Mimonectidae, Hyperiidae, Phronimidae and Anchylomeridae. Kongliga Svenska Vetenskapsakademiens Hanlingar, 22: 1-434, Plates 1-18.

Bowman, T. E. 1960. The pelagic amphipod genus Parathemisto (Hyperiidea: Hyperiidae) in the North Pacific and adjacent Arctic Ocean. Proc. U.S. Nat. Mus. 112:343-392.

Bowman, T. E. 1973. Pelagic amphipods of the genus Hyperia and closely related genera (Hyperiidea: Hyperiidae). Smithsonian Contr. Zool. No. 136. 76 pp.

Bowman, T. E. 1978. Revision of the pelagic amphipod genus Primno (Hyperiidea: Phrosinidae). Smithsonian Contr. Zool. No. 275. 23 pp.

Bowman, T. E. and Hans-Eckhard Gruner. 1973. The families and genera of Hyperiidea (Crustacea: Amphipoda). Smithsonian Contr. Zool. No. 146. 64 pp.

Bowman, T. E., C. D. Meyers and S. D. Hicks. 1963. Notes on associations between Hyperiid amphipods and medusae in Chesapeake and Narranganset Bays and the Niantic River. Chesapeake Sci. 4:141-146.

Brusca, G. J. 1967. The ecology of pelagic Amphipoda I: species accounts, vertical zonation and migration of Amphipoda from the waters off southern California. Pacific Sci. 21:382-393.

Brusca, G. J. 1973. Pelagic Amphipoda from the waters near Oahu, Hawaii, excluding the family Scinidae. Pacific Sci. 27:8-27.

Burrell, V. G., W. A. Van Engel, and S. G. Hummel. 1974. A new device for subsampling plankton samples. J. Cons. Int. Explor. Mer. 35:364-6.

Chevreux, E. and L. Fage. 1925. Amphipodes. Faune de France. 9:1-488.

Claus, C. 1887. Die Platysceliden. 25 plates. 77 pp.

Dahl, E. 1959b. The amphipod <u>Hyperia galba</u> an ecto-parasite of the jelly-fish <u>Cyanea capillata</u>. Nature, 183:1749.

Dick, R. I. 1970. Hyperiidea (Crustacea: Amphipoda) Keys to south African genera and species and a checklist. South African Mus. 57:25-86.

Dunbar, M. J. 1946. On <u>Themisto libellula</u> in Baffin land coastal waters. J. Fish. Res. Bd. Canada. 6:419-434.

Fage, L. 1960. Oxycephalidae. Amphipodes Pelagigues. Dana Report. 9:1-145.

Flores, M. and G. J. Brusca. 1975. Observations on two species of hyperiid amphipods associated with the ctenophore <u>Plèruobronchia bachei</u>. Bull. S. California Acad. Sci. 74:10-15.

Grant, G. C. 1977. Zooplankton of the water column and neuston. Chapter 4 in Middle Atlantic Outer Continental Shelf environmental studies, Volume II, Chemical and Biological Benchmark Studies. Prepared by Virginia Institute of Marine Science, Gloucester Pt., Va. under Contract No. 08550-CT-5-42 with the Bureau of Land Management, U. S. Department of Interior. 138 pp.

Grant, G. C. 1979. Middle Atlantic Bight Zooplankton: second year results and a discussion of the two year BLM-VIMS Survey. Va. Inst. Mar. Sci. Special Report in Applied Marine Science and Ocean Engineering No. 192. 236 pp.

Grice, G. D. and A. D. Hart. 1962. The abundance, seasonal occurrence, and distribution of the epizooplankton between New York and Bermuda. Ecol. Monogr. 32:287-307.

Harbison, G. R. 1976. Development of Lycaea pulex Marion, 1874 and Lycaea vincentii Stebbing, 1888 (Amphipoda: Hyperiidea), Bull. Mar. Sci. 26:152-164.

Harbison, G. R. and L. P. Madin. 1976. Description of the female Lycaea nasuta Claus, 1879 with an illustrated key to the species of Lycaea dana, 1852 (Amphipoda: Hyperiidea). Bull. Mar. Sci. 26:165-171.

Harbison. G. R., D. C. Briggs and L. P. Madin. 1977. The associations of Amphipoda Hyperiidea with gelatinous zooplankton--II. Associations with Cnidaria, Ctenophora, and Radiolaria. Deep Sea Res. 24:465-488.

Hoffer, S. A. 1972. Some aspects of the life cycle of Parathemisto abyssorum (Amphipoda: Hyperiidea) in The Gulf of St. Lawrence. Canadian Zool. 50:1175-1178.

Holmes, S. J. 1905. The amphipods of southern New England. Bull. U. S. Bur. Fish. 24:457-530.

Hurley, D. E. 1955. Pelagic amphipods of the suborder Hyperiidea in New Zealand waters. I. Systematics. Trans. Roy. Soc. New Zealand. 83:119-194.

Hurley, D. E. 1956. Bathypelagic and other Hyperiidea from California waters. Allan Hancock Foundation Publ. Occas. Pap. 18:1-25.

Hurley, D. E. 1969. Amphipoda Hyperiidea. Pages 32-34, sheets 1 and 2 in Antarctic Map Folio Series, Folio II, Distribution of Selected Groups of Marine Invertebrates in Waters South of 35°S Latitude. American Geographical Society.

Kane, J. E. 1966. The distribution of Parathemisto gaudichaudi (Guer.), with observations on its life history in the 0° to 20°E sector of the southern ocean. Discovery Rep. 34:163-198.

Kielhorn, W. V. 1952. The biology of the surface zone zooplankton of a boreo-artic Atlantic Ocean area J. Fish. Res. Bd. Canada, 9:223-264.

Lorz, H. and W. G. Pearcy. 1975. Distribution of Hyperiid amphipods off the Oregon coast. J. Fish Res. Bd. Canada. 32:1442-1447.

Madin, L. P. and G. R. Harbison. 1977. The associations of Amphipoda Hyperiidea with gelatinous zooplankton I. Associations with Salpidae. Deep Sea Res. 24:499-563.

Morris, B. 1975. The neuston of the North West Atlantic. Ph.D. dissertation, Dalhousie Univ., Halifax, Nova Scotia.

Pirlot, J. M. 1929. Resultats zoologiques de la croisiere Atlantique de (1-Armauer Hansen (Mai-Juin 1922)). 1. Les Amphipodes Hyperides. Mem. Soc. Roy. Sci. Liege (3)15(2):1-196.

Pirlot, J. M. 1930. Les Amphipodes de l'expedition du Siboga. Premiere Partie, Les Amphipodes Hyperides (a l'exception des Thaumatopsidae et des Oxycephalidae) Siboga Exp. Monogr. 33a:1-55.

Ruzecki, E. P., C. S. Welch, and D. L. Baker. 1977. Physical oceanography and climatology. Chapter 3 in Middle Atlantic Outer Continental Shelf Environmental Studies, by Virginia Institute of Marine Science, Gloucester Pt., Va. under Contract No. 08550-CT-5-42 with the Bureau of Land Management, U. S. Department of Interior. 246 pp.

Sears, M. and G. L. Clarke. 1940. Annual fluctuations in the abundance of marine zooplankton. Biol. Bull. 79: 321-328.

Sheader, M. and F. Evans. 1974. The taxonomic relationship of Parathemisto gaudichaudi (Guerin) and P. gracilipes (Norman), with a key to the genus Parathemisto. J. Mar. Biol. Assoc. U. K. 54:915-924.

Sheader, M. and F. Evans. 1975. Feeding and gut structure of Parathemisto gaudichaudi (Guerin). J. Mar. Biol. Assoc. U. K. 55:641-656.

Shih, Chang-tai. 1969. The systematics and biology of the family Phronimidae (Crustacea: Amphipoda). Dana Rep. 14:1-100.

Shoemaker, C. R. 1945. The Amphipoda of the Bermuda Oceanographic Expeditions 1929-1931. Zoologica. 30:185-266.

Shulenberger, E. 1976. Spatial and associational pattern in the hyperiid amphipod assemblage of the north Pacific central gyre. Ph.D. dissertation University of California, San Diego, California.

Stebbing, T. R. 1888. Report on the Amphipoda collected by H.M.S. Challenger during the years 1873-1876. Zoology 29:1-1713, plates 1-210.

Stephensen, K. 1924. Hyperiidea-Amphipoda (Part 2: Paraphronimidae, Hyperiidae, Dairellidae, Phronimidae, Anchylomeridae). Report on Danish Oceanographical Expeditions 1908-1910 to the Mediterranean and Adjacent Seas, 2:151-252.

Tencati, J. R. and S. R. Geiger. 1967. Pelagic amphipods of the slope waters of northeast Greenland. J. Fish. Res. Bd. Canada 25:1637-1650.

Thurston, M. H. 1976. The vertical distribution and diurnal migration of the crustacea Amphipoda collected during the Sond Cruise, 1965. II. The Hyperiidea and general discussion. J. Mar. Biol. Assoc. U. K. 56:383-470.

Vecchione, M. 1979. Planktonic molluscan faunal structure across a large scale environmental gradient. Ph.D. Dissertation. School of Marine Science, College of William and Mary, Williamsburg, Virginia. 153 pp.

Whiteley, G. C. 1948. The distribution of larger planktonic Crustacea on Georges Bank. Ecol. Monogr. 18:233-264.

Von Westernhagen, H. 1976. Some aspects of the biology of the hyperiid amphipod Hyperoche medusarum. Helgolander wiss. Meeresunters. 28:43-50.

Yoo, K. 1971. The biology of the pelagic amphipod, Primno macropa Guer., in the western North Pacific I. Systematics. Korean J. Zool. 14:132-138.

Yoo, K. 1972. The biology of the pelagic amphipod, Primno macropa Guer., in the western North Pacific II. Geographical distribution and vertical distributional pattern. Korean J. Zool. 15:87-91.